Harboring Chaos

by
Jeffrey A. Anderson

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Abstract:

Hurricane shelters have become the unknown point of last resort for many coastal communities. Harboring displaced populations during a hurricane and it's chaotic aftermath are no longer seen as a need in a coastal commuintes evacuation strategy. The dangerous situation this strategy poses is being amplified by an increasing coastal population density along the Gulf Coast of the United States while the infrastructure to support mass scale evacuations is not growing in proportion to the population. Communities must face the realization that given the unpredictable nature of hurricanes, evacuation may not be possible for all citizens given the time frame before landfall.

This thesis takes the role of harboring evacuees and wraps it into and around the program of a stadium. Being an icon of the city, the stadium will provide a foundation for inserting the hurricane shelter into the core fabric of coastal cities. Using the landscape and transportation infrastructure that feeds the stadium in its existing role, the shelter will engage the city as an icon to the memory of the threat, a point of protection from that threat and a point of aid following the threat.

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The following people helped me tremendously through this process, without their support, guidance, mentorship and friendship I wouldn't have succeeded:

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Nic Rader

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This book is dedicated to my family who have supported me through every step of my education.

I would also like to extend the most sincere thank you too Kathryn Donnelly who has supported me with love, a shoulder to cry on and an incredible mind that always knew what questions to ask to keep me moving forward.

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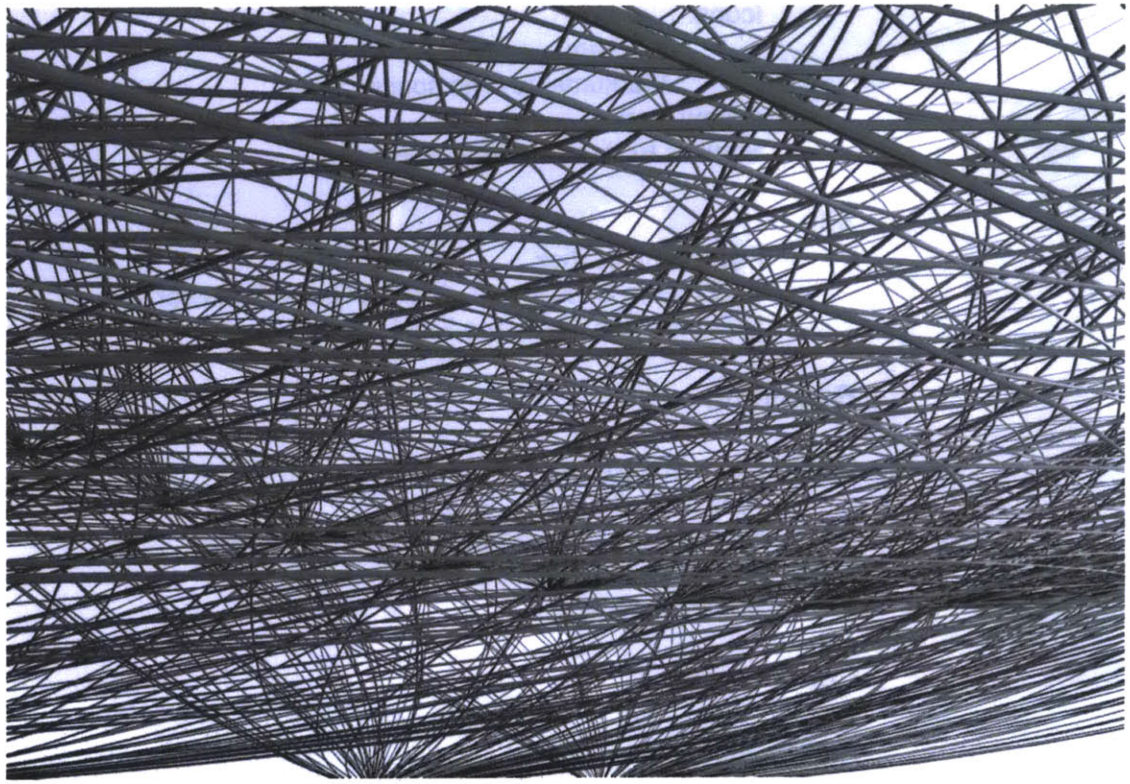


Rendering of a model produced with 21 points
generatating 1500 arcs. **Chaos**

Harbor(ing)

n.Something that physically protects, especially from danger

*v1. To give **refuge** to*

v2. To provide with often temporary lodging

(The American Heritage Dictionary, 2000)

Chaos

*1. A condition or place of great disorder or confusion. 2. A disorderly mass; a **jumble**: The desk was a chaos of papers and unopened letters. 3. often Chaos The disordered state of unformed matter and infinite space supposed in some cosmogonic views to have existed before the ordered universe. 4. Mathematics A **dynamical system** that has a sensitive dependence on its initial conditions. 5. Obsolete An abyss; a chasm.*

(The American Heritage Dictionary, 2000)

Image of hurricane shelter in Pensicola Florida.
Source Unknown.

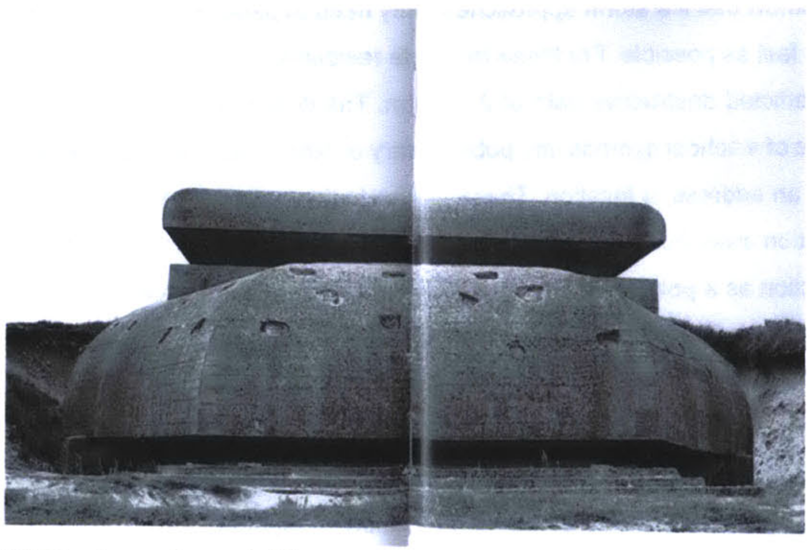
Hidden Shelter / Hidden Threat

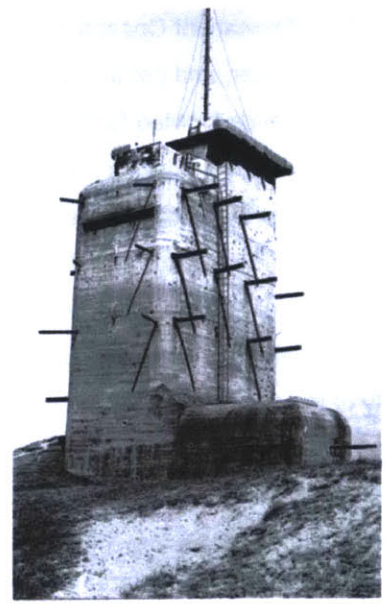
"Public shelters should always be used as a last resort."

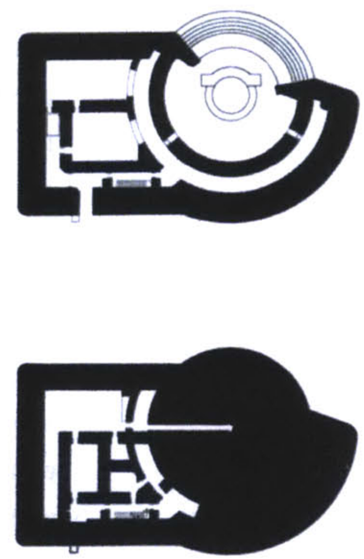
(Bob Lay, Director Brevard County Emergency Management Office, May 23, 2006 Florida Today)

Hurricane evacuation strategies are dependant on people heeding this advice and taking to the roads to escape an approaching storm. Emergency management officials for decades have stood by the idea that the best means of escape is to flee. Permanent Coastal residents know that if a storm approaches, they need to pack the kids, pets and valuables into the car, and get as far away as fast as possible. For these fortunate residents shelters are the hotels and homes of friends located far from the predicted destructive path of the storm. The designated shelters within the community are hidden within the enclosure of a school gymnasium, public library or other civic building. Shelters are generally known only to the residents as an address, a location. These places fit the technical requirement of shelter based on construction standards, location away from storm surge and, in some cases, special needs accessibility. They do not express visually their function as a point of refuge, they exist as a number on a street. Function as shelter is masked behind the facade of any one of a non descript set of building types. This masking denies the possibility of the shelter becoming a central component to communities' preparation for, refuge from and rebuilding after a storm. Stripping away that mask will allow the shelter to serve the community as a reminder of the threat that exists, a civic building that houses key community activities when the threat is not present, a known point of refuge when the threat is present and a place to return in the days, weeks and months following landfall.

In proposing this shift in thought behind what the hurricane shelter is and how it is integrated with the community this thesis is attempting to find an architecture for shelter which captures its new role. What constitutes an architecture that responds to the threats of the hurricane? To the needs of the evacuee? To the needs of the community?







WWII bunkers on the coast of France.
(Virilio, 1991)

Icons: as Bunkers

Bunkers constructed along the north coast of France during WWII were looked at in two ways for this thesis: As impressive structures that attempt to rationalize what form is required to handle a perceived threat, a shell fired by a ship miles off the coast, and as a network of deterrents that functions as shelter by providing a visual and physical barrier to an attacking force. As physical shelter they were engineered to withstand forces of unimaginable magnitude; their forms are expressive, massive and responsive to the surroundings. They were just as offensive as they were defensive and as a result putting yourself into one of these immediately made any occupant a much more visible target. There function as a perceived shelter to the residents of the cities and towns within which they were constructed can be imagined as profound.

Bunkers became a pseudo-shelter that while not physically providing protection, because they served the community, protecting by deterring. The perception that any threat would be less likely to engage the community based on the positioning of this physical element made the bunker an important physical element within the community. Military installations, as extreme as they seem, may in many cases act as deterrents which protect the communities within which they exist.

Bunkers in this sense become icons not because they were massive elements in the landscape, but in there massiveness they presented a deterrent to a threat that would endanger the community. Hurricane shelters cannot deter a hurricane from striking a community, but the shelter can become the element in the community that serves to remind of the threat, keep the community prepared for this threat and provide protection for those who have no other means of escaping. Iconicizing the shelter will bring a level of awareness to the threat of storms, the need for preparation and the need for community action in time leading up to and following the storm.

How does a forboding implication produce a condition of shelter by lessening the chance of a threat?



Swiss bunkers intented to blend with the landscape.
(Fabrizio, 2006)

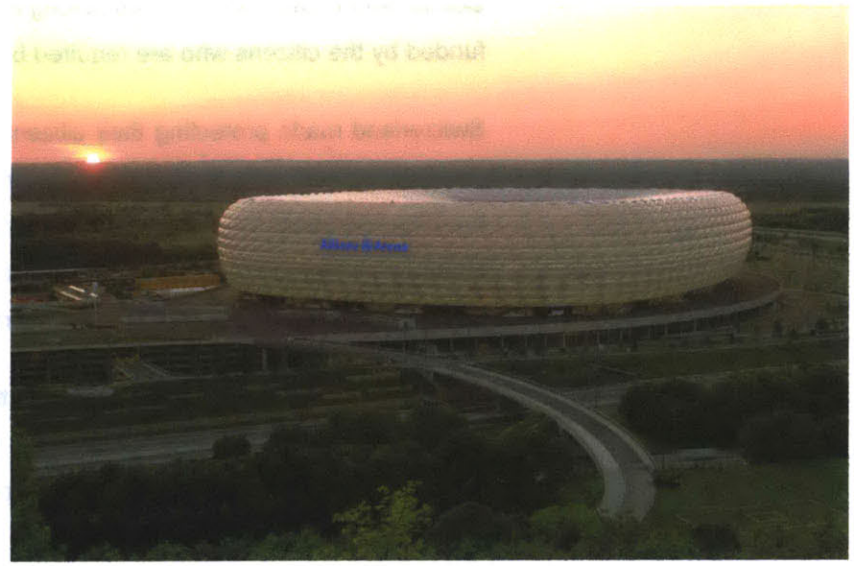
Switzerland has built a civil defense infrastructure, which has become the most comprehensive in Europe. In the years following WWII the threat of large scale war throughout Europe caused by an unprovoked attack from the east became a real possibility. Understanding their place in Europe as a landlocked, mountainous and neutral country, the Swiss embarked on a government sponsored program to create a civil defense network to protect it's citizens from the first wave of an attack. Every citizen was required to build a sophisticated bomb shelter within their home and be prepared to survive for two weeks following the first attack to give the government time to begin distributing aid. Today there are over 350,000 individual shelters throughout Switzerland. A large number have been decommissioned, and today many citizens belong to a vast network of community shelters. Community shelters are partially funded by the citizens who are required by law to either belong to one or have one in their house.

Switzerland made protecting their citizens from any of a number of unknown natural and man made disasters a priority. Its written into the laws of the state, and while there has been a drastic reduction in its requirements over the past few years the system is being adapted to meet new threats. The Swiss have been able to transform the idea of shelter into a national point of pride that all partake in. The citizens are aware of threats, what and where to go when one becomes eminent and understand what to do in its aftermath.

Switzerland's shelters are iconic because they are omnipresent. They don't stand as beacons along a coast calling attention to themselves in effort to deter a threat, but they are an infrastructure of protection from threats that can't always be deterred. Shelters need to respond to the needs of the community within which they are built and the Swiss have done exactly that.

Shelters along the Gulf Coast need to learn from both of these examples. Hurricane shelters need to become icons both as a physical constructions that call attention to the threat and their purpose, but also need to become part of a larger network of combined infrastructures to ensure total evacuation. The shelter will not solve the problem alone, but this thesis is particularly interested in the shelters capacity to become the piece of the infrastructure that begins the discussion and calls attention to a threat that is often to easy to forget about.

Facade detail of the Coliseum
Rome, Italy
(www.worth1000.com)



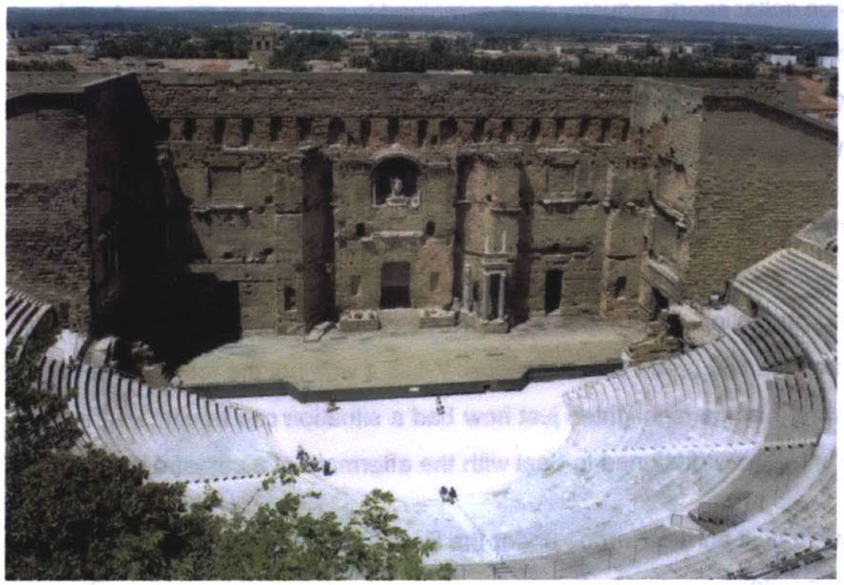
Allianz Arena
Munich, Germany
(img51.echo.cx)

Icons: Stadiums as civic spaces

The stadium has been a monument in our cities for close to 3000 years. In b.c. 736 the first know stadium was built in Olympia, Greece for the fist Olympic Games (en.wikipedia.org). Since then civilizations have built great stadiums around the world as places for sport, music and entertainment. The Romans were some of the most prolific stadium builders with examples constructed across their ancient empire. Worldwide stadiums are international destinations, bringing tourism and economic boom to the cities within which they are built. In the United States, more so than any other country, the sports stadia, and the billion dollar sports industry have combined to create a multitude of modern stadiums. The newest of these stadiums go beyond simple venues for sport to be viewed and now combine multiple different attractions under the same roof. Cities now compete with one another for stadium glory in an attempt to continually re-invent the modern stadium (Wilbur, 2000).

Historically stadiums have served many other roles that go far beyond their original purpose for short term inhabitation. As cities have dealt with war, catastrophic natural disaster and political strife, the stadium has been adapted to become a place for harboring, torture and protection. Most recently Hurricane Katrina forced thousands of New Orleans residents to flee into the Superdome as a last resort for evacuation. While it was not the first time this stadium was used as a shelter, the days following Katrina highlighted just how bad a situation can become when the buildings we use to harbor populations are improperly designed to deal with the aftermath of a catastrophe.

Hundreds of amphitheaters and stadiums were built across Europe under the Roman Empire. While many of these structures were destroyed there are a few examples that still function today. One of the best preserved is in Orange France. Constructed around AD100 this amphitheater serves today as an active venue for theater and music. After being excavated in the 19th century it was found that this 5000 seat amphitheater was turned into a small village in the 16th century. As religious war ravaged the region, the citizens of Orange moved inside the relative safety of the ampitheater walls and constructed an entire village. For nearly a century this village was expanded upon, filling the entire amphitheater from stage to top seating (www.musee-jacquemart-andre.com).



Theatre Antique d'Orange
Orange, France
(Philippe Gromelle)

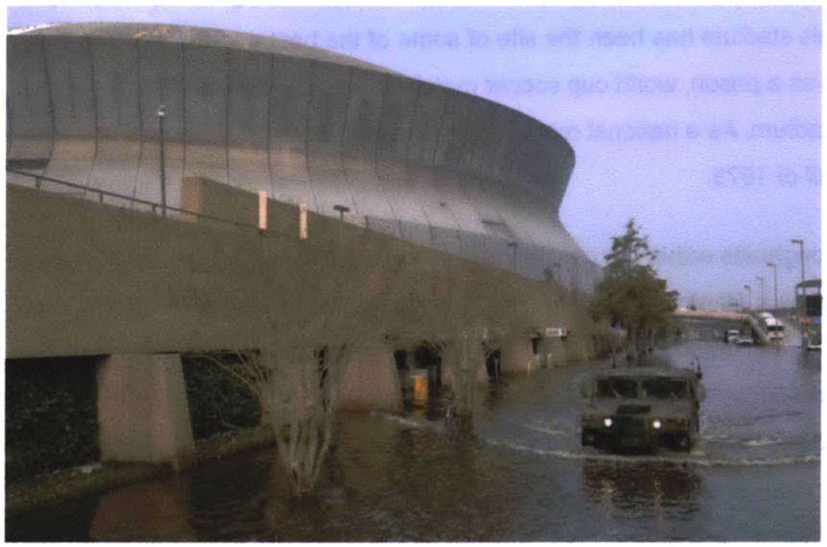
Maracanã Stadium
Rio de Janeiro, Brazil
(www.rionow.com)

In this case there was safety within the massive walls of the amphitheater while the roof was completely open allowing for ventilation, light and water.

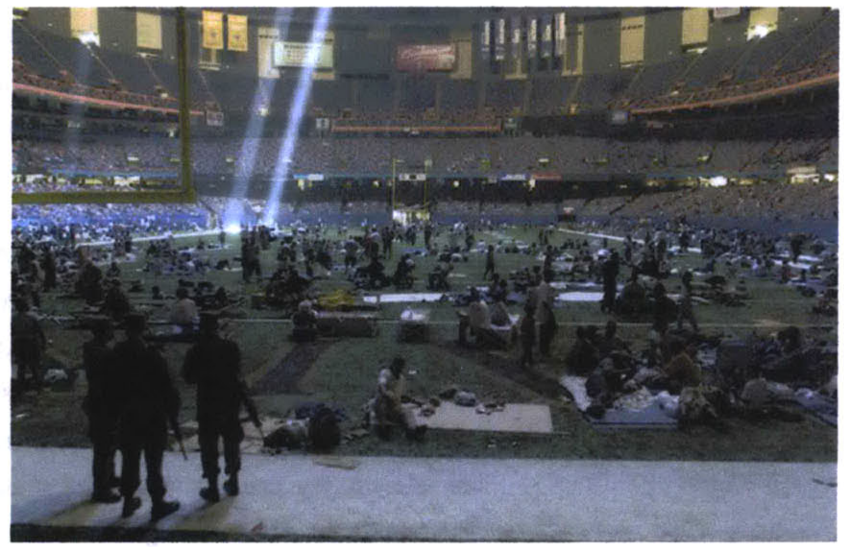
National stadiums in many South American Countries and African states have been used a pulpits for the display of a governments power, to its citizens and the world. Estadio Nacional Chile was the site of a massive urban concentration camp following the coup that placed Augusto Pinochet in power of Chile in 1973. Within days of his empowerment, thousands of Chileans and foreigners were rounded up and placed in the stadium. Many were tortured and brutally murdered within the confines of the stadium that at one point had served as a refuge camp for people fleeing World War II Europe. Built in 1938, this stadium has been the site of some of the best and the worst events of the 20th century in Chile. Following its use as a prison, world cup soccer matches, presidential inaugurations and massive concerts have taken place in this stadium. As a national monument there has been little discussion of the atrocities that took place there in the later half of 1973.

Occupying forces have used stadiums as strongholds within the city during times of war. Recently the Iraqi National Soccer Stadium was used by U.S. led forces as a staging point within the city for numerous missions. At the start of the first Gulf War in the early 1990's, U.S. forces quickly took over the Iraqi National Stadium and soon filled the interior of the stadium with a small base. Knowing they had control of the skies over Baghdad and a relatively safe perimeter around the stadium, the U.S.-led coalition had a field hospital, armory and vehicle staging center within the stadium. The use of this open air stadium provided relative security while maintaining enough exposure to the environment to take advantage of natural light and fresh air.

In these instances the use of the stadium has been re-imagined in a way never imagined by the original designer. Stadiums are designed to bring people together in front of peace time sports, international competition and entertainment spectacle. What would a stadium be if it was designed to be used in times of crisis and peril? The stadium wouldn't transform into this role, but present it as a constant reminder to threats that exist within a place that are out of the control of the people and institutions that are intended to protect them.



Army Humvee area of Superdome post
Hurricane Katrina.
New Orleans, LA
(Department of Defense)



Inside Superdome post Hurricane Katrina
New Orleans, LA
(AP Photo)

A New Icon: Physically unchanged but its memory forever tarnished

August 29th 2005 Hurricane Katrina moved inland over southeast Louisiana and forced millions to evacuate from the Florida Panhandle to New Orleans, Louisiana and points further west. In the city of New Orleans thousands of people unable to evacuate were told to make there way to the Superdome as a last resort for shelter.

The Superdome performed its function as a shelter from the storms immediate effects intact. While the structure sustained damage that eventually broke away sections of the roof, the stadium protected the people inside. Once the storm passed, the function of the stadium shifted from protection against the storm to harboring thousands from a hostile outside environment. As the city began to flood thousands more rescued residents were brought to the dome and the temporary population inside swelled to over 25,000. The stadium was completely ill equipped to handle this mass of people. It was not designed for natural lighting of interior spaces, had no passive ventilation system and the plumbing system failed. Rest rooms were backed up leaving raw sewage flooding into the hallways. Darkness befell all but the main playing field and seating area of the stadium. The field was covered with temporary cots while others took refuge in the seating areas. The corridors and rest rooms became places where violence, robbery and rape took place (Treaster, 2006). The building was completely un-fit to act as an extended shelter and within days of landfall plans were put into place to evacuate the dome and transport people to other shelters from Texas to Massachusetts. The buses attempting to reach the stadium to evacuate people encountered problems do to the location of the Superdome. The stadium is located in a part of the city that sustained massive damage to infrastructure and was experiencing slowly rising flood waters, which made the evacuation process slow. These problems increased the time it took to evacuate the dome adding to the frustration of people trapped inside (Treaster, 2006). The Superdome's failures were caused by a scenario the designers never anticipated.

The Superdome failed as a civic apparatus not because it wasn't a good place for entertainment, but because when it was called upon to function as crucial piece of infrastructure in an emergency it couldn't cope with the environment. How can a shelter for tens of thousands of people not fail when called upon following a disaster?

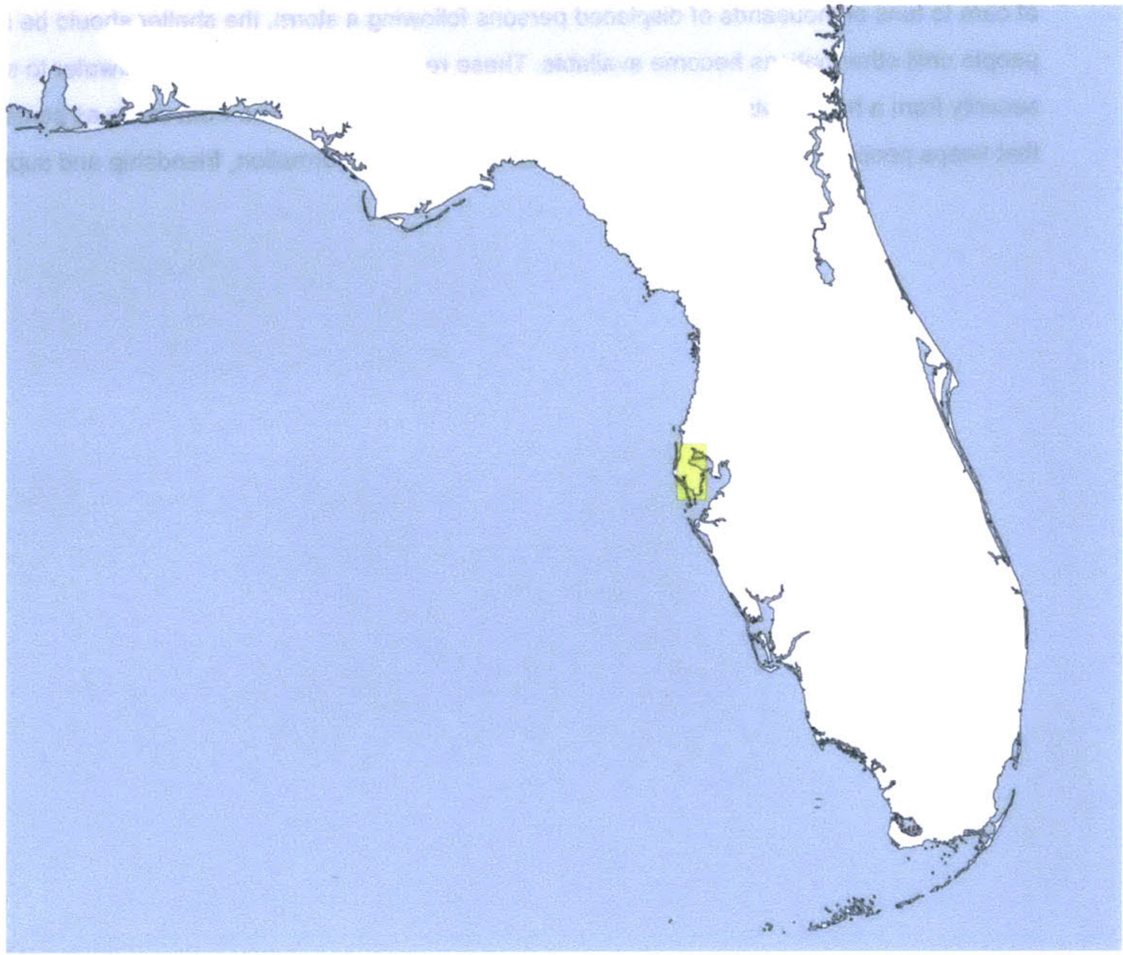
Shelter: Protect, Provide, Prevent

Hurricane Katrina created a situation where thousands of people were placed in an shelter ill equipped for anything beyond physical protection from wind, debris and rain. Was the Superdome any less equipped to deal with harboring people after a storm than any other official shelter? Looking at Shelter spaces in Pinellas county reveals that the answer is probably no. Shelters are generally in spaces with no natural light or natural ventilation so following a storm they too would have stagnant air and dark spaces. They generally have no plumbing facilities which would function following a storm, or if they did work they would quickly back up as the sewage system would be inundated with water across the county.

The shelters would also have significant crowding of people as the county figures each person in a shelter will be given 10sq. feet of space. An average adult male when laid out on the ground takes up nearly 12sq. feet. The average coffin has roughly 16sq. feet. Added to the crowding will be the items that the county asks you bring with you which include, folding chairs, cots, pillows and blankets, special dietary needs, prescription medications, baby diapers, formula, Disaster Survival Kit, books, puzzles and other quiet games to pass the time. (www.pinellas-county.org) If we were to think of all this fitting into 10sq. feet it is immediately clear that there would be no room left for the person.

In 1997 the Sphere Project was started by numerous world humanitarian relief agency's in an effort to provide tools to mitigate disaster responses and policies. The major tool they have developed is a constantly evolving handbook that outlines the basic needs of a refugee and the way that shelters/camps should provide for these needs. Part of these guidelines are space requirements that provide minimum standards for floor areas in long term sheltering instances. Sphere recommends a minimum of 36 sq. feet for any long term shelter condition. They do make provisions that take into account the number of people using the shelter will most likely decrease dramatically following the immediate physical dangers of any disaster, they never recommend less than 20 sq. feet per person.

In Pinellas County the existing shelters do not respond to any condition of sheltering beyond a few days. Long term sheltering will be provided by a number of different sources from Federal Emergency Management Agency trailers, hotels, friends and tent cities. While it is impossible to imagine a single shelter providing months or years of care to tens of thousands of displaced persons following a storm, the shelter should be able to provide for these people until other options become available. These requirements vary from food/water to sustain life, physical security from a harsh outside environment, a safe environment as free from crime as possible and an environment that keeps people interacting with one another exchanging information, friendship and support.



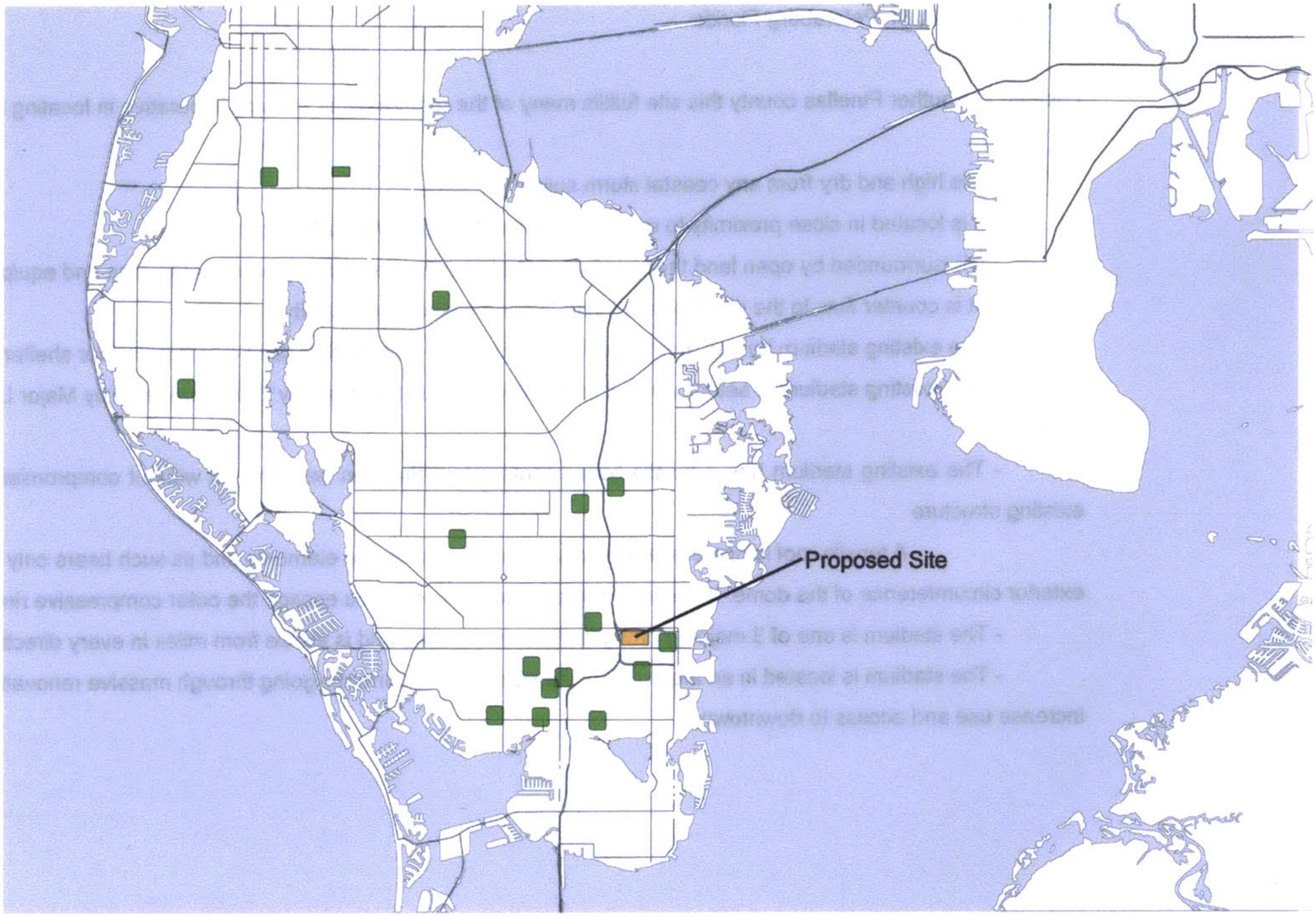
A map highlighting Pinellas County
in realtion to the rest of Florida.

Site:

Tropicana Field, St. Petersburg Florida

Located in Souther Pinellas county this site fulfills many of the requirements that are imperative in locating a shelter:

- It is high and dry from any coastal storm surge
- It is located in close proximity to road, air and sea transportation infrastructure
- It is surrounded by open land that can be used as staging areas for emergency vehicles and equipment
- It is counter flow to the direction of evacuation increasing accessibility
- The existing stadium has an abundance of extra square footage that can be programed for shelter
- The existing stadium is set for a major renovation or re-construction by 2010 mandated by Major League Baseball
- The existing stadium has a tensile based roof system that can be removed without compromising the existing structure
    - A tensile roof is one that has no continuous compressive elements and as such bears only on the exterior circumference of the dome. It is essentially a clear span once you escape the outer compressive ring.
- The stadium is one of 3 major sporting facilities in the area and is visible from miles in every direction
- The stadium is located in an area of St. Petersburg that is currently going through massive renovations to increase use and access to downtown.



A map of southern Pinellas County showing proposed site and existing shelters.

WHAT COULD HAPPEN HERE?

The Saffir-Simpson Scale has been used by meteorologists since 1969 as a way to compare the damage that tropical storms inflict. This scale was used the National Hurricane Center to project what flood waters might look like in Pinellas County under each category storm. A total of 750 simulated tests from various points in the Tampa Bay area for each category were combined to create these images. An individual hurricane could look different than the scenario's presented here, depending on which direction the storm comes from and other factors

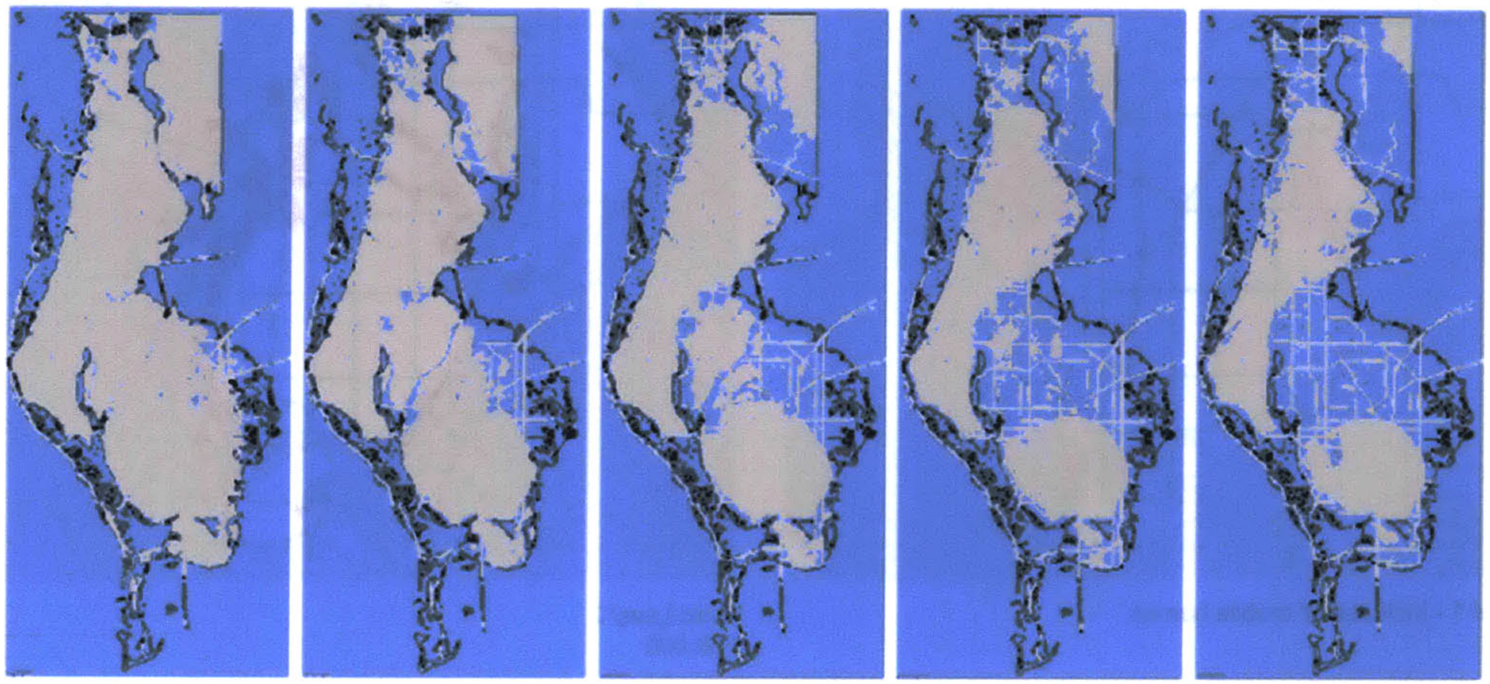
Category 1
Winds 74-95 mph
Storm surge 4-5 feet

Category 2
Winds 96-110 mph
Storm surge 6-8 feet

Category 3
Winds 111-130 mph
Storm surge 9-12 feet

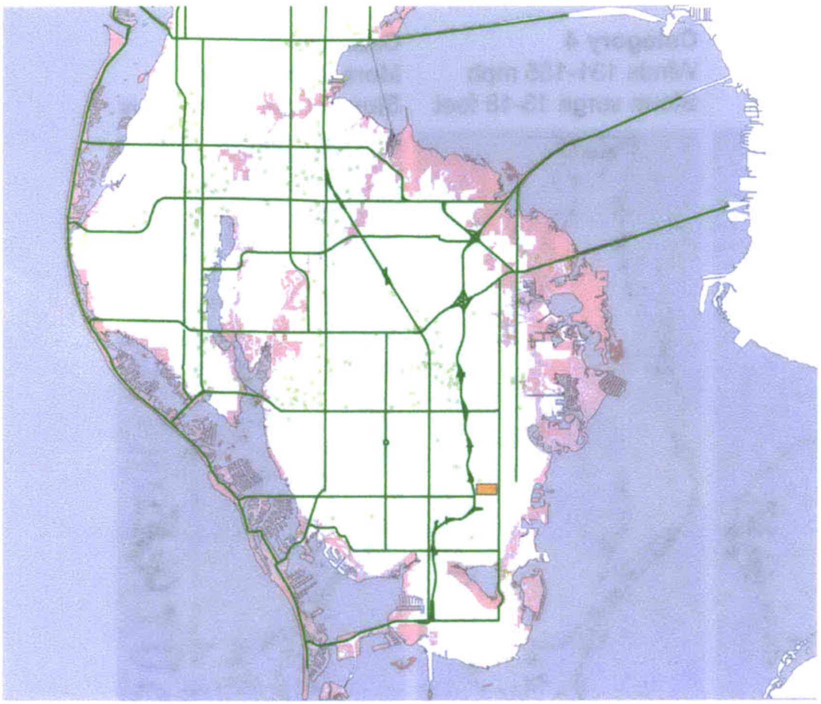
Category 4
Winds 131-155 mph
Storm surge 13-18 feet

Category 5
More than 155 mph
Storm surge 18 feet plus

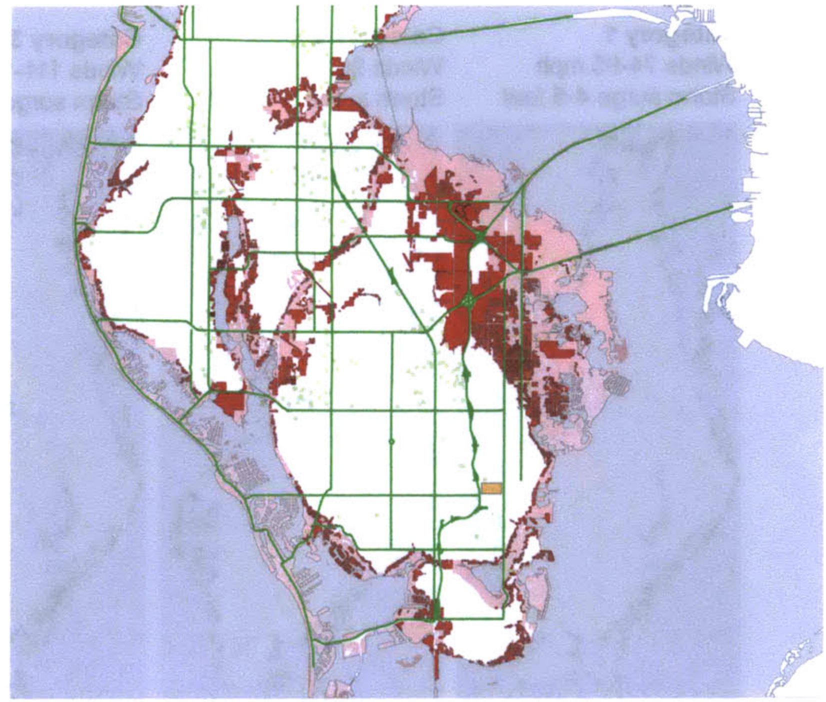


Jeff Goerzem
St. Petersburg Times

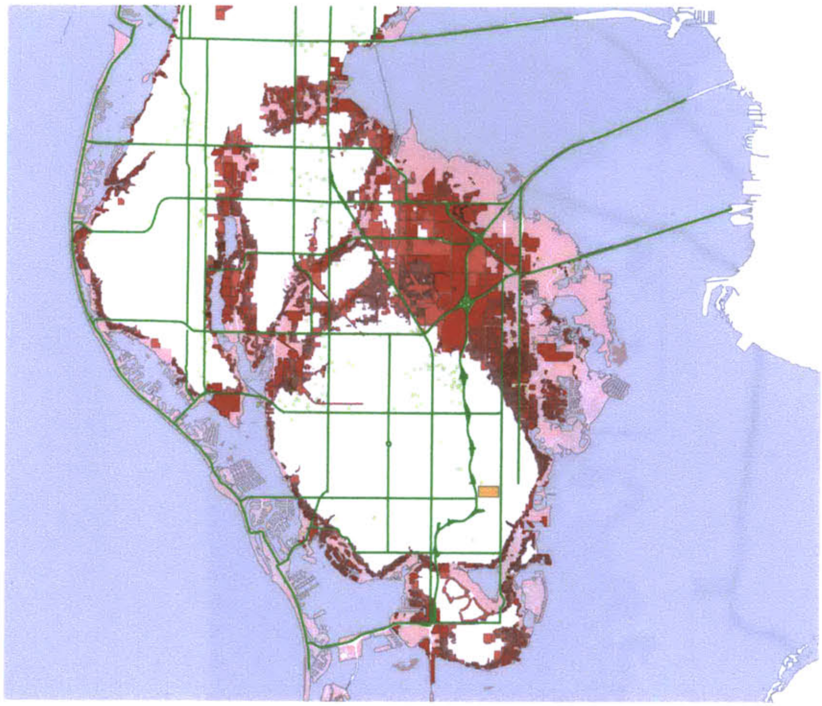
Pinellas Evacuation Zones and Evacuation Routes



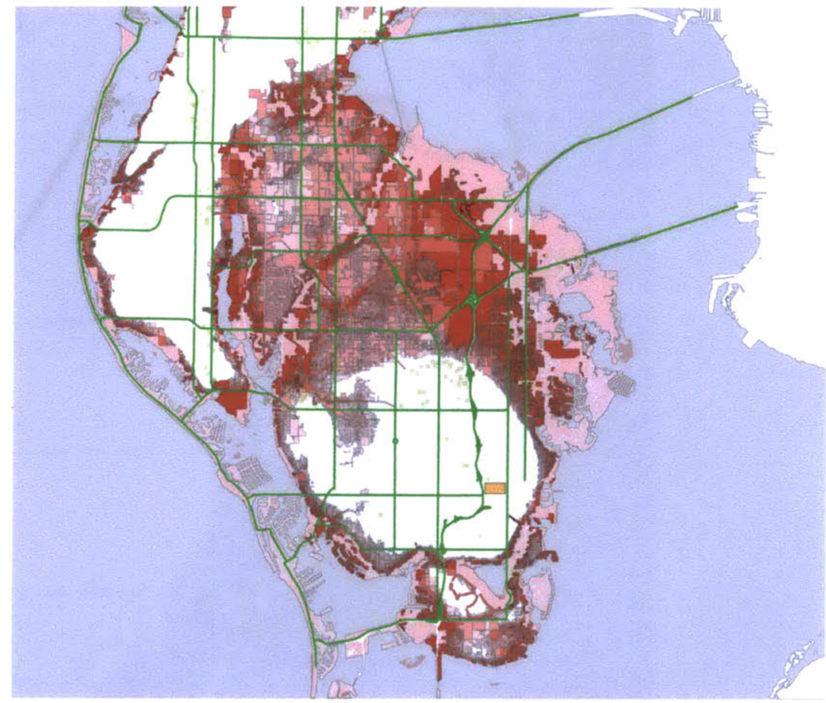
Evac Level 1 - Includes all mobile homes
400,000



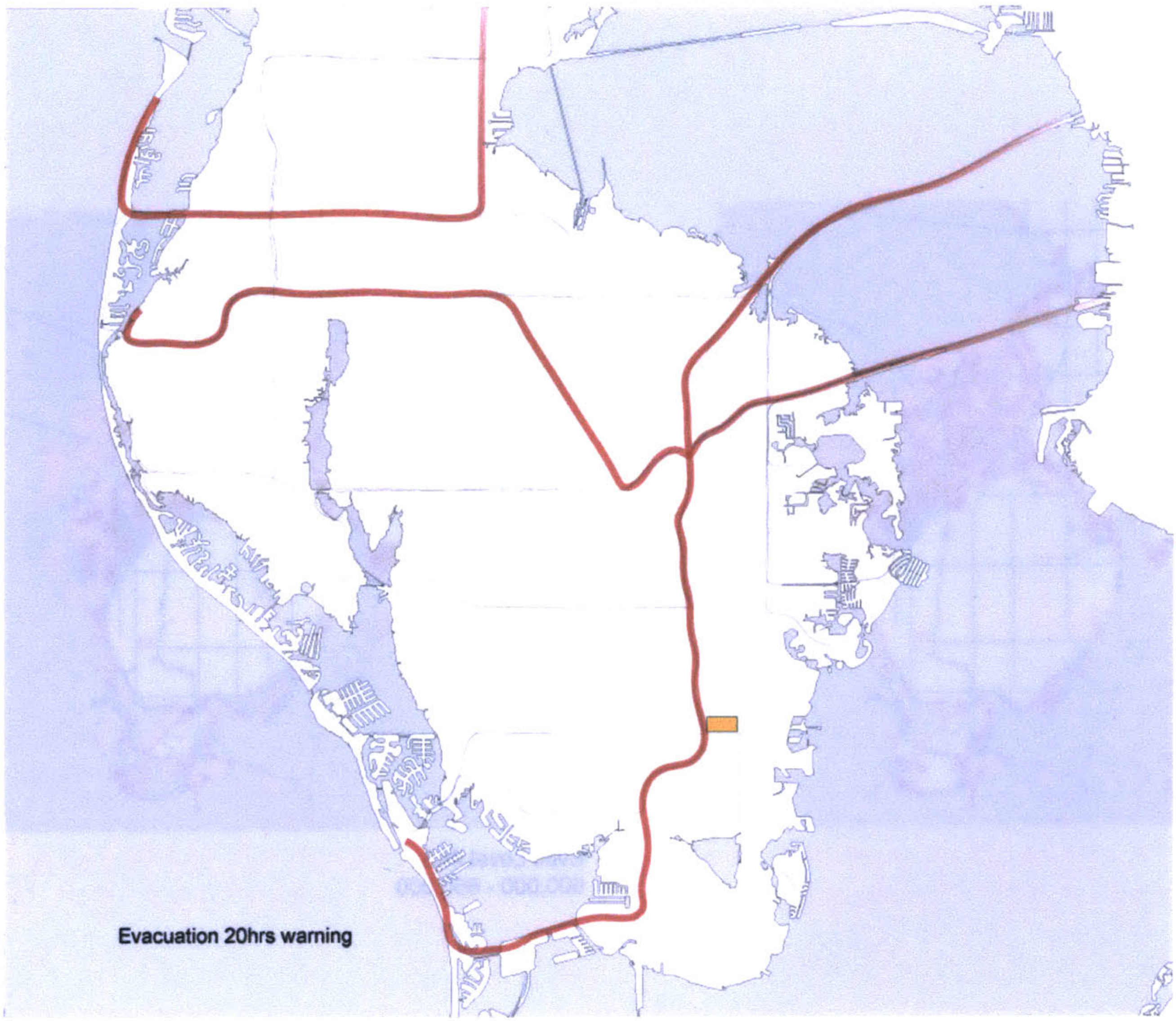
Evac Level 2
500,000



Evac Level 3
575,000



Evac Level 4&5
600,000 - 650,000

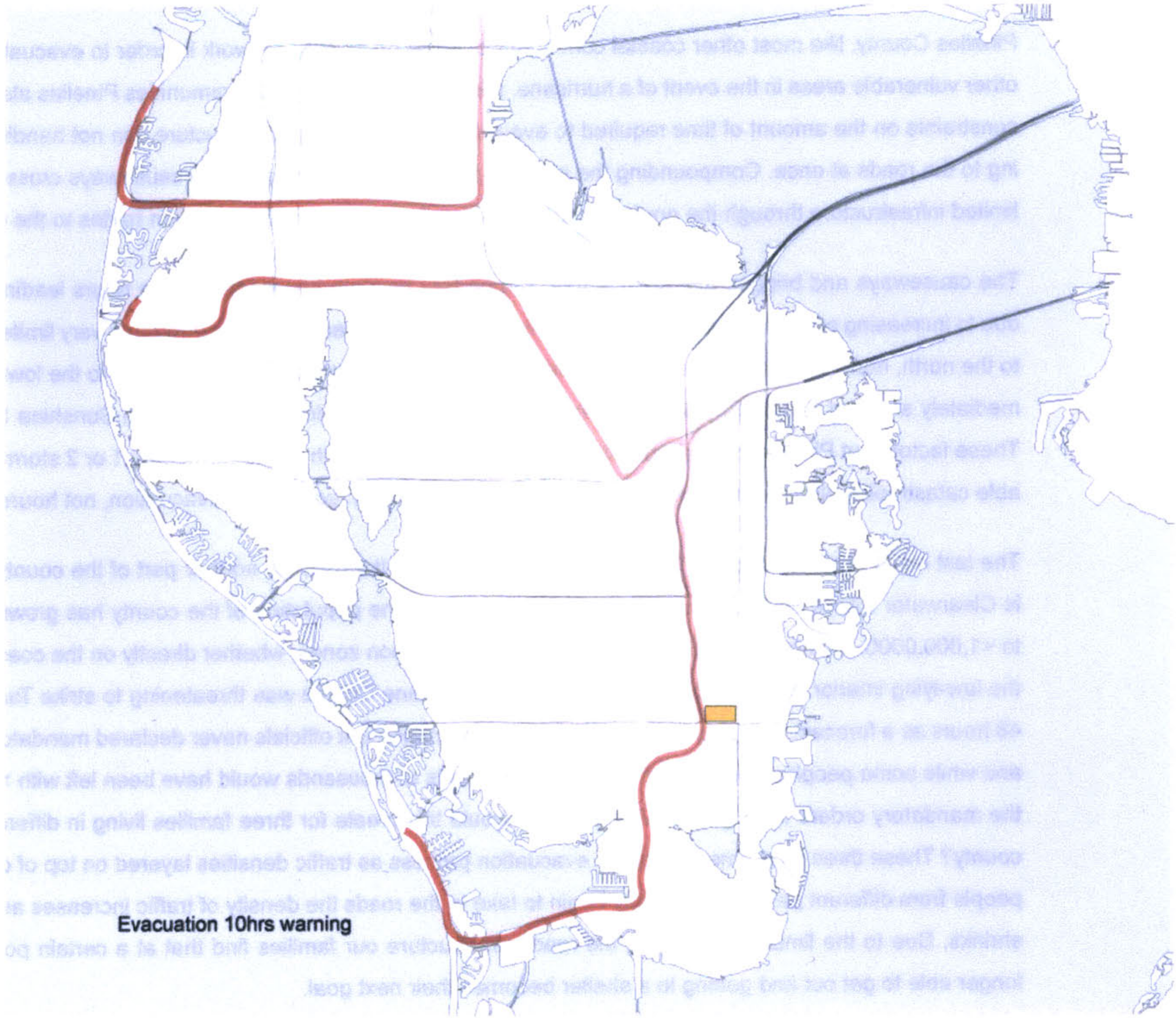

Evacuation 20hrs warning

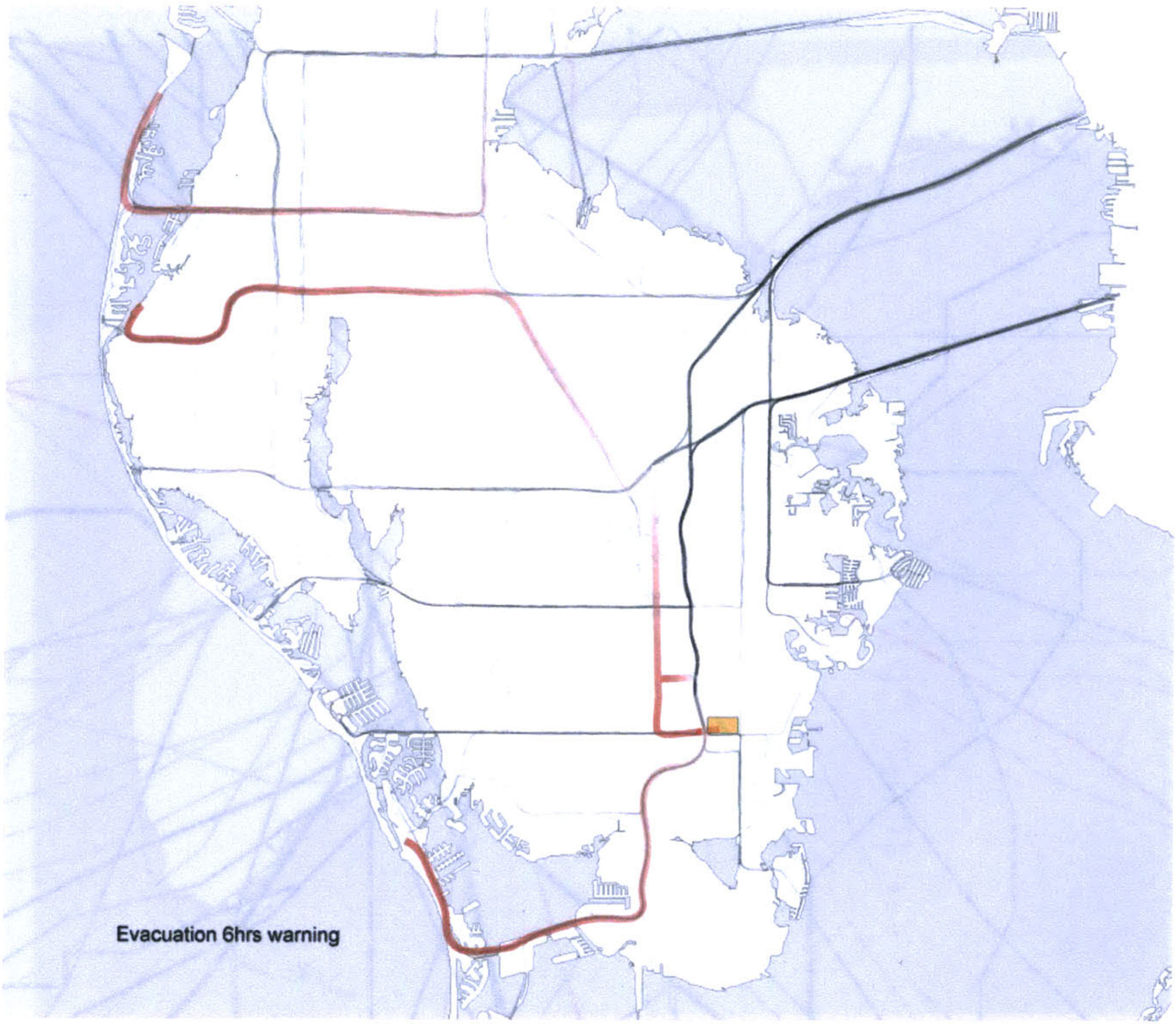
Evacuation Strategy _ Chaotic Storm Behavior

Pinellas County, like most other coastal communities, relies on its road network in order to evacuate low-lying and other vulnerable areas in the event of a hurricane. Like many other coastal communities Pinellas also faces serious constraints on the amount of time required to evacuate as the existing infrastructure can not handle everyone taking to the roads at once. Compounding the problem for Pinellas is its reliance on causeways crossing Tampa Bay, limited infrastructure through the northern part of the county and a lack of evacuation routes to the south.

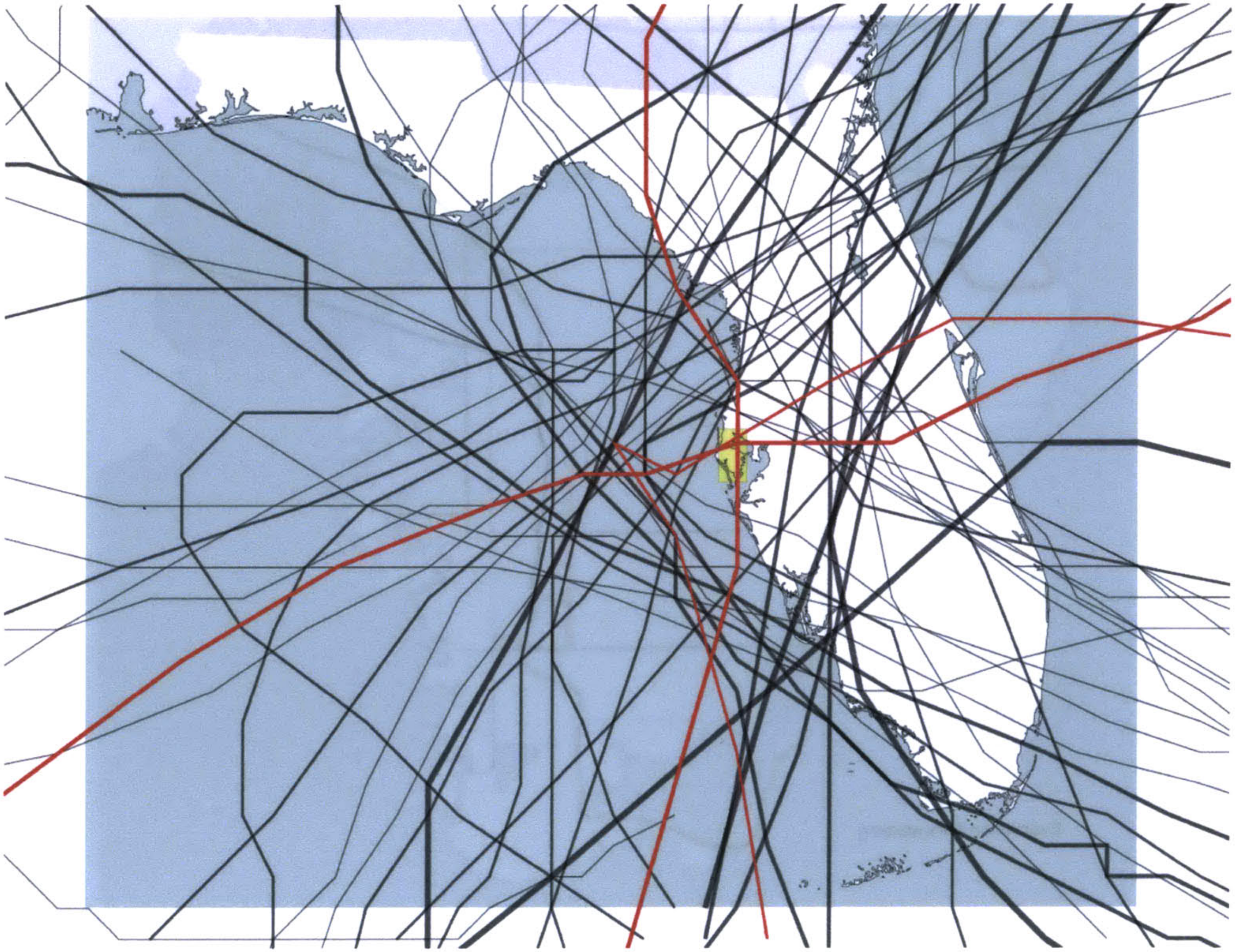
The causeways and bridges that span across Tampa Bay become impassable in the hours leading up to landfall due to increasing sea level and wave activity. This effectively re-directs all traffic through a very limited road network to the north, none of which is interstate. To the south there are no evacuation routes due to the low-lying areas immediately south of Tampa Bay and the treacherous winds that would be impacting the Sunshine Skyway Bridge. These factors put Pinellas in a difficult situation even when faced with a weak Category 1 or 2 storm. If the unthinkable catastrophic storm were to impact the county days would be required for evacuation, not hours.

The last major storm to impact Pinellas County was in 1921. It struck the norther part of the county in what today is Clearwater Beach and downtown Clearwater. Since then the population of the county has grown from >50,000 to <1,000,0000. Of those 1,000,000 over 60% live in evacuation zones, whether directly on the coast or in many of the low-lying interior portions of the county. In 2004 Hurricane Charlie was threatening to strike Tampa Bay within 48 hours as a forecast Category 4 storm. Emergency management officials never declared mandatory evacuations and while some people did evacuate voluntarily, hundreds of thousands would have been left with >24 hours once the mandatory orders were given. What possibly would this create for three families living in different parts of the county? These three diagrams look at the evacuation process as traffic densities layered on top of one another. As people from different parts of the county begin to take to the roads the density of traffic increases as the time scale shrinks. Due to the limited capacity of the road infrastructure our families find that at a certain point they are no longer able to get out and getting to a shelter becomes their next goal.


Evacuation 10hrs warning


Evacuation 6hrs warning

150 Years of Hurricane Tracks Within 65nm of the St. Petersburg

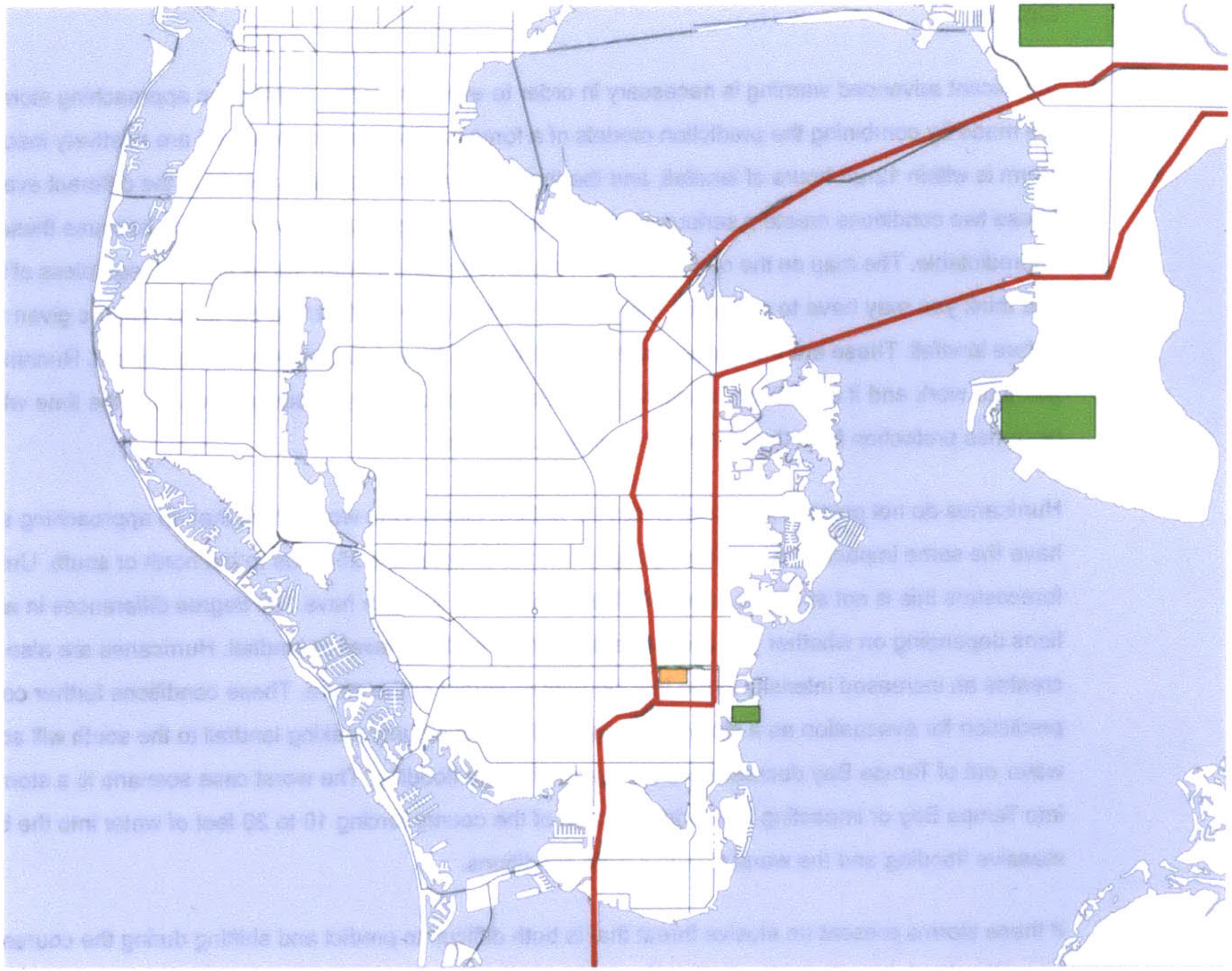


Chaos

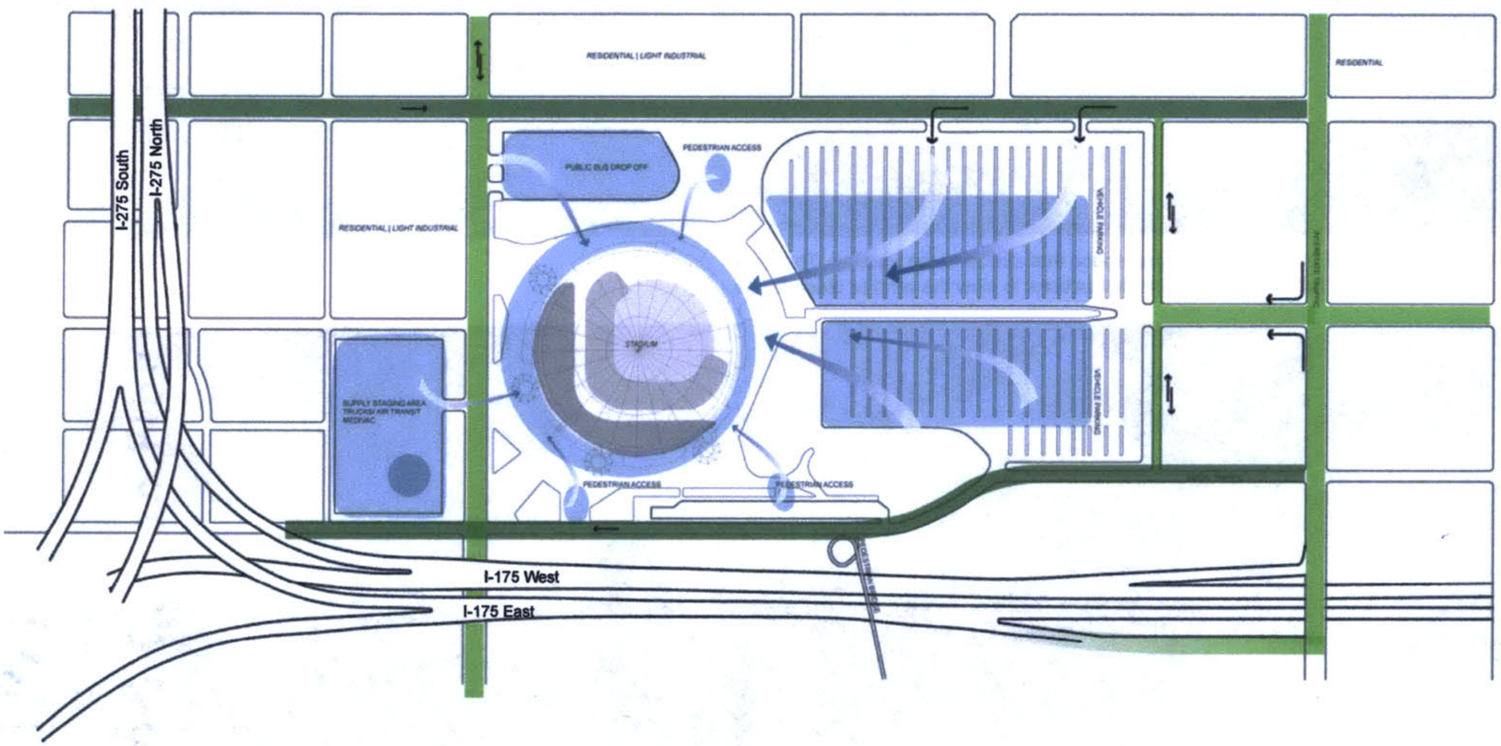
Significant advanced warning is necessary in order to evacuate in the event of an approaching storm. Evacuations are made by combining the prediction models of a forecast hurricane track, which are relatively inaccurate until the storm is within 12-24 hours of landfall, and the threat the storm posses to people in the different evacuation zones. These two conditions create a serious challenge for emergency management officials because these storms are so unpredictable. The map on the opposite page shows how chaotic storm tracks are and regardless of how much time you think you may have to evacuate, storms can change track so fast that the order may be given with >12 hours before landfall. These are the scenarios that make it clear the existing network is insufficient. Running is not always going to work and it is in these situations that shelters become key to saving lives. It is the time when the shelter becomes protection from the storm and its physical effects.

Hurricanes do not present a rational wind field pattern either. One would think that an approaching storm would have the same impact on a community regardless of whether it is 25 miles to the north or south. Unfortunately for forecasters this is not at all the case. Hurricanes spin and as such have 180 degree differences in wind directions depending on whether you are to the right or left of the eyewall at landfall. Hurricanes are also moving which creates an increased intensity in the leading right quadrant of the storm. These conditions further complicate the prediction for evacuation as a storm that impacts Pinellas County making landfall to the south will actually push water out of Tampa Bay decreasing the amount of surge flooding. The worst case scenario is a storm running up into Tampa Bay or impacting the middle section of the county forcing 10 to 20 feet of water into the bay; causing massive flooding and the worst possible wind conditions.

If these storms present an elusive threat that is both difficult to predict and shifting during the course of the storm impacting land, how does the shelter physically respond to protect the people harboring inside?



This map shows major land and air infrastructure through Pinellas and western Hillsborough County. Both major north south connectors through Pinellas County which connect to Hillsborough County pass within 1/2 mile of the site. Within 2 miles of the site is a small commuter airport with MacDill Airforce Base 8 miles away and Tampa International Airport at a distance of 15 miles. There are also numerous land to sea transfer points within 2 miles of the site.



This site map shows major local road connections and traffic flow directions. It also highlights areas of the site which can serve alternate functions when the stadium is being used as a shelter.

This panorama shows the vast parking lot and open space that surround the stadium. The area surrounding is also noticeable flat leaving very few obstructions to slow the wind or block debris.

This panorama is taken at a distance of about 1.5 miles from the site at the edge of Tampa Bay. Here it is visible that running in any direction is not possible from Pinellas County. Water surrounds it on 3 sides.

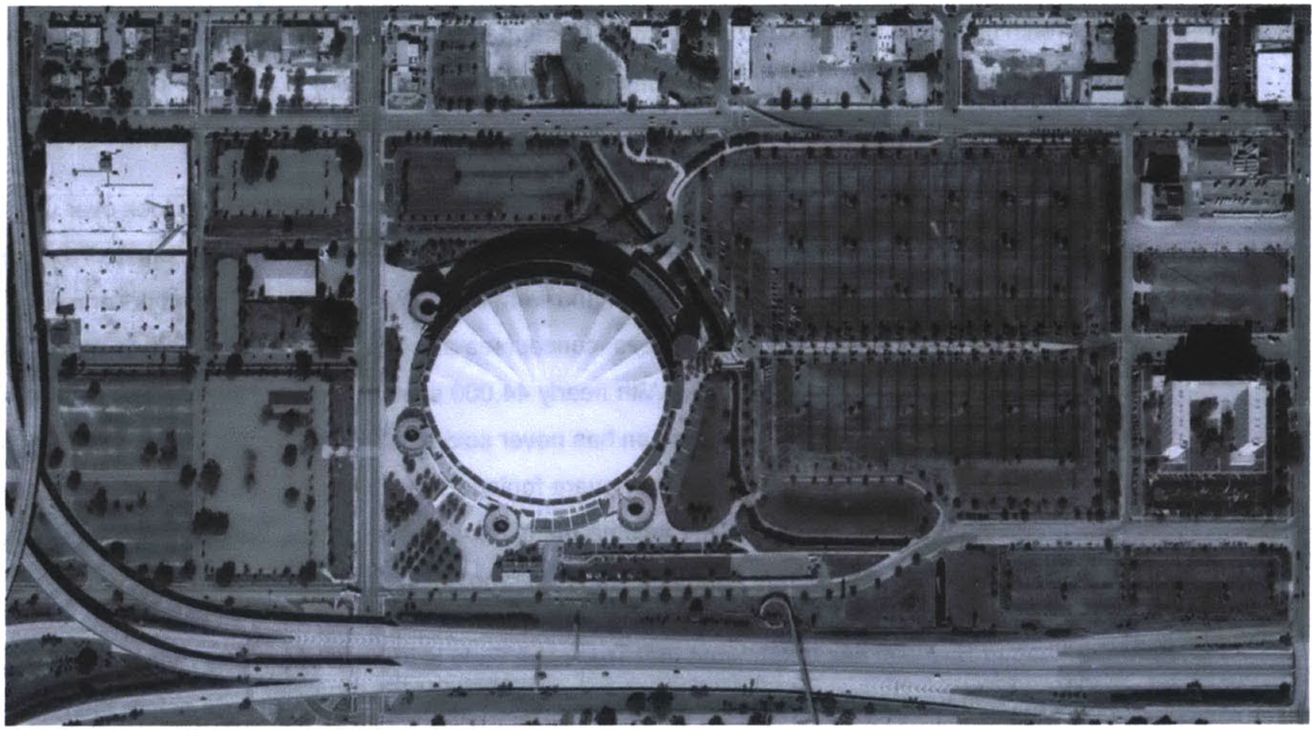
Inside Tropicana Field showing roof structure
St. Petersburg, FL
(wikipedia)

Existing Icon: Tropicana Field

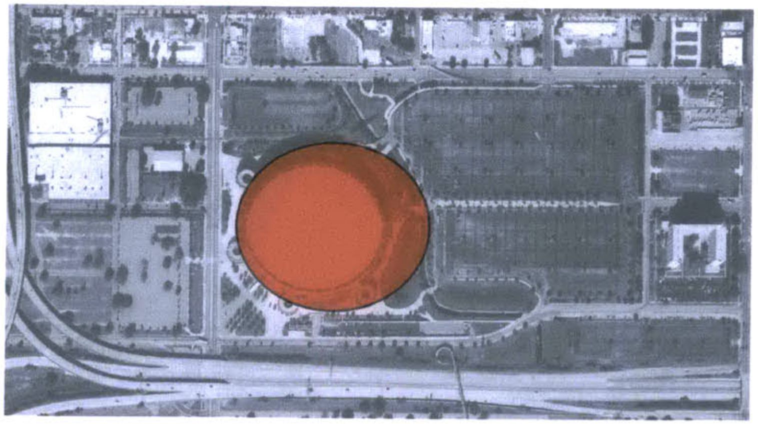
Built by the City of St. Petersburg to attract a Major League Baseball team to the Tampa Bay area in 1990, the stadium has gone through numerous changes in its use. Originally designed by HOK Sport the most innovative feature of the domes structure is its tensegrity roof structure. The roof spans nearly 700' with no continuous compressive element spanning the interior of the dome. This system provides a lightweight solution to such a long span roof system with minimal interference from structural element in the playing field. Another innovative feature of the dome is that its slanted in one direction (from home plate towards center field) in an effort to reduce the internal volume thus decreasing air conditioning loads.

The stadium was originally named the Suncoast Dome until the Tampa Bay Lighting took over use of the facility in 1993 renaming it the Thunderdome. In 1997 Tampa Bay finally got its Major League Baseball expansion team after which the dome was renamed Tropicana Field, and went through a massive 70 million dollar renovation. The renovation included the addition of new entrances, concourses and luxury boxes adding tens of thousands of square feet with no increase in seating capacity. With nearly 44,000 seats it is one of the largest baseball stadiums in the country and as of the end of the 2006 season has never sold out. This leaves the possibility to significantly reduce the number of seats in order to increase the square footage available to possible shelter space. The massive size of the stadium from both a footprint and volume measurement also leaves the possibility to significantly alter the inserted pieces of structure added during the 1997-98 renovation freeing up more area.

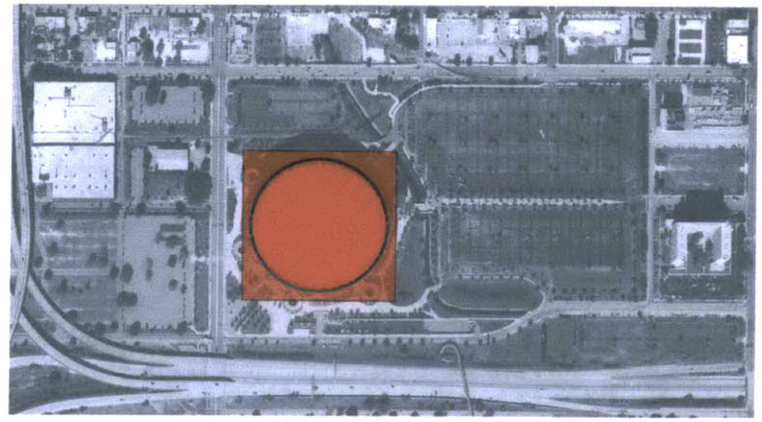
Major League Baseball has determined that Tropicana Field is in need of a major renovation or reconstruction by 2012. The Devil Rays have been given notice that if significant change is not made before then they will not have a home to play in. Dismal ticket sales and numerous complaints by fans and players about the quality attending/playing in the stadium leave St. Petersburg in a difficult situation. They don't have the money for a new stadium nor do they have the space to build a new stadium near by. This thesis proposes to combine the city's need for a major renovation to its stadium and its need for a new hurricane shelter to address an increasing problem for its evacuation strategy.



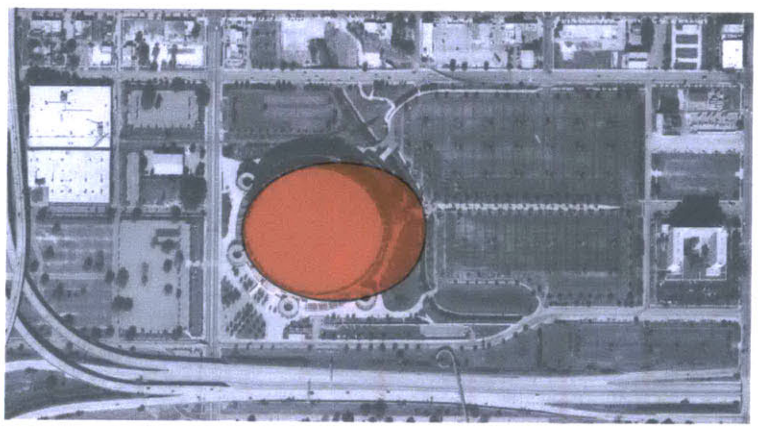
Aerial of Tropicana Field
(Pinellas County GIS)



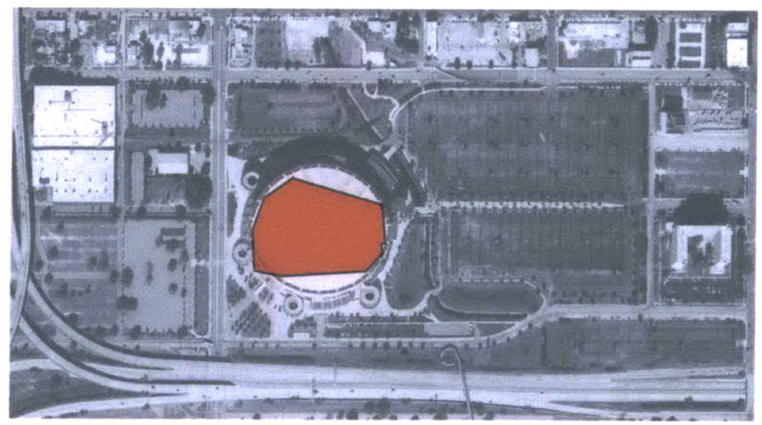
Estadio municipal do Maracana:
1950, Rio de Janeiro Brazil
Multipurpose, Soccer main activity, Open air partial seat covering
140,000 current, 200,000 when open
No added program, all circulation / support



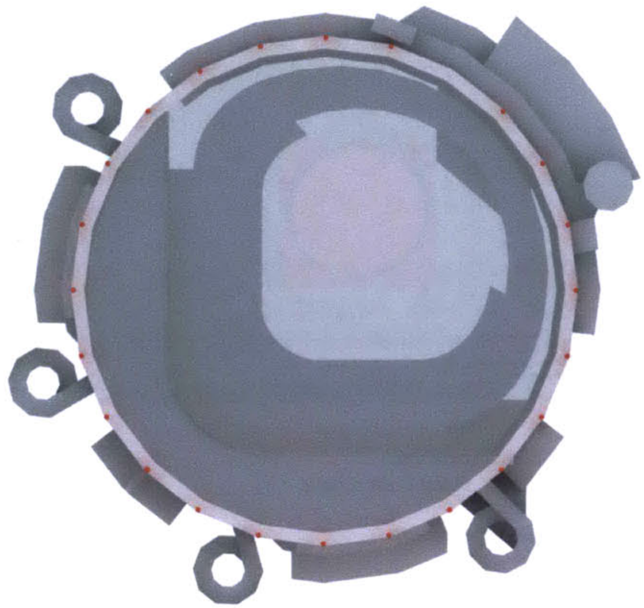
Superdome:
1975, New Orleans, Louisiana
Multi Purpose Arena, Fixed Roof: Dome
Up to 80,000
Luxury Suits, parking structure



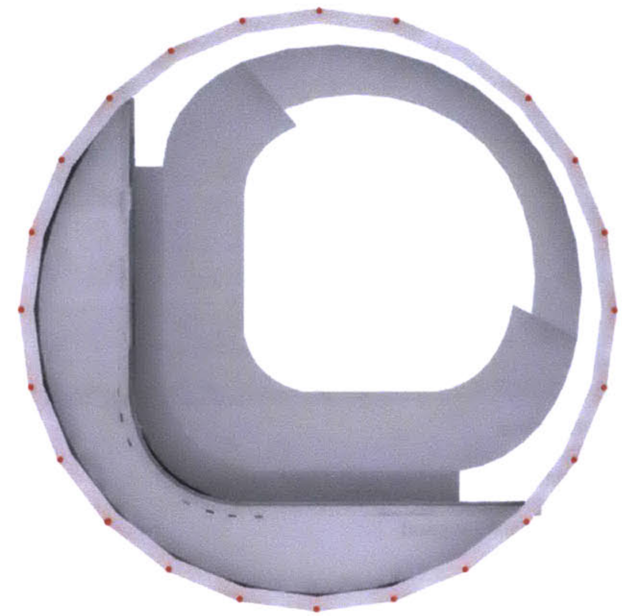
The Horseshoe, Ohio Stadium:
1922, Columbus Ohio, Ohio State University
Football Stadium, Open Air
Up to 110,000
Classrooms, offices, Luxury Suits



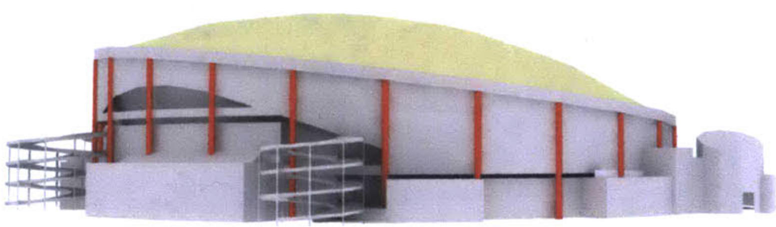
Fenway Park:
1911, Boston, MA
MLB Park, Open air, partial seat covering
Up to 38,000
Luxury Suits, Roof Top Bar



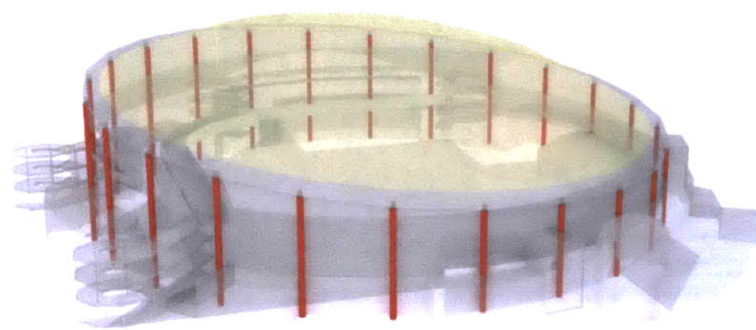
Plan of existing stadium with columns in red



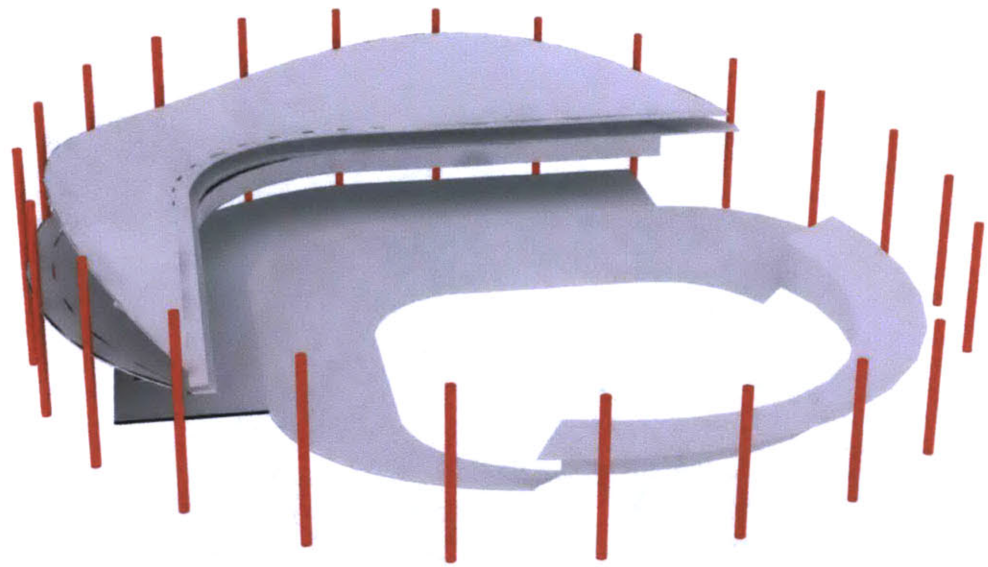
Plan of stadium with non essential elements removed



Elevation of stadium, structural column in red



Aerial perspective with all existing columns in red



Distilling the existing stadium down to its key components was an important step to see what components of the stadium were important to keep and which were not. Due to the stadiums use of a tensile roof system there were no continuous compressive structural elements that spanned the center of the stadium. This effectively makes it possible to remove the roof without compromising the structural integrity of the stadium. Twenty four main structural columns provide the bulk of the vertical support of the stadium with smaller columns inside the stadium that handle part of the load of the upper seating. The diagram above shows the elements of the stadium that this thesis sees as key and cannot be removed. Not represented in the diagram are the concrete shear walls that give the columns lateral stability, which will be kept. The most important element of the existing stadium in the development of the shelter are the twenty four columns. They are the key to the existing stadiums structure and are used as the points where the structure of the shelter will attach.

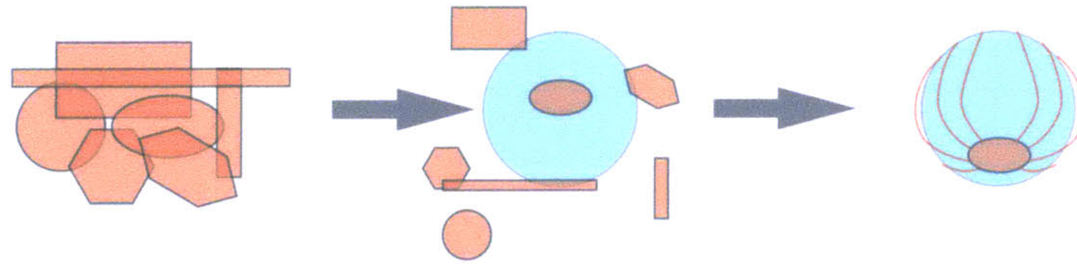
Image of first known parasite which
completely replaces a hosts body part.
(Smit)

Beginning

If we think about these conditions as the driving force behind the design of the shelter than what is a large idea that can be the inspiration behind the architecture? The design process of this thesis answers that question with a focus on filtering and responding to contrasting conditions and forces. This project begins with a community posed with an eminent threat, an existing iconic structure within that community and the need to make a statement about the need for shelters functioning as key civic apparatuses.

Layering becomes both the process of deriving form and the process of deriving the program of the spaces within the project. Utilizing generative computation systems, ones that manipulate data based on differentiating inputs into a relational system, in conjunction with analog process's, ones that shift data based on 1 to 1 manipulation of inputs, such as traditional three dimensional NURB modeling, this thesis attempts to find an outcome hidden within this production of layered systems.

Degenerative

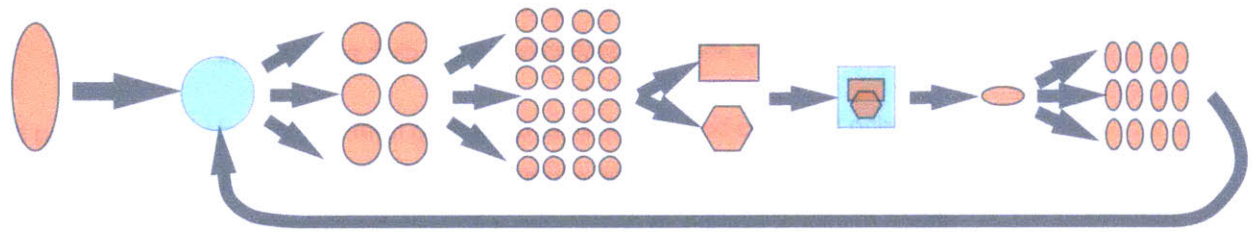


Leave Snail - Segmented body: head, mouth, tail, legs. Can swim and feed.

Invade Crab - Sheds body parts 1 by 1

Final Stage - No body parts, mouth gone. Roots spread through shell seeking nutrients. Lays eggs.

Mutation



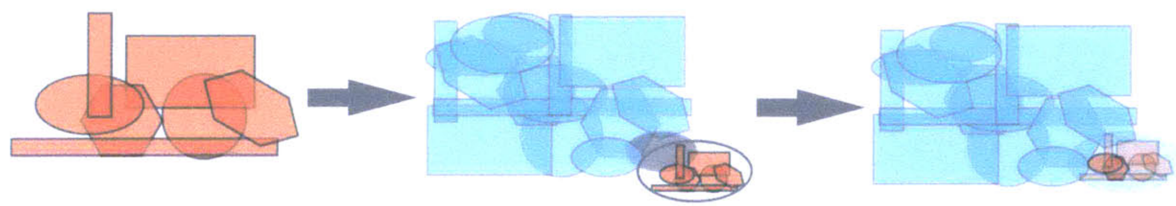
Transfer - Mosquito gives sporozite to human during bite.

Mutation 1 - Sporozite invades liver, hatchs into thousands of Merozites, they in turn multiply in the blood stream.

Mutation 2 - Some merozites mutate into macromagots which are sexual. They are then transfered back to a mosquito during a bite.

Mutation 3&4 - Macromagots produce ookinete offspring, which then transform into sporozites and the whole process starts over.

Transplant



Invasion - Crustation enters fish through gills and attaches to tongue. Feeds off the tongues artery slowly causing atrophy.

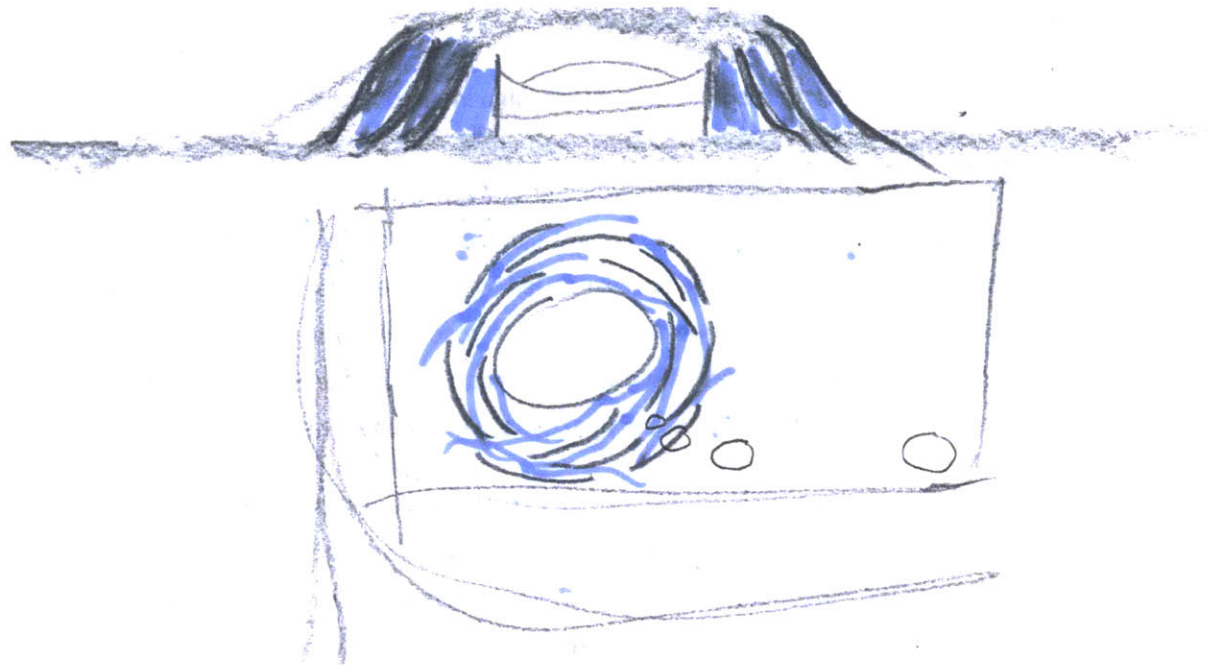
Transplant - Tongue falls off, crustation takes over function of tongue. Begins to feed of food particles while fish eats, reducing dependancy on fish supplied nutrients. No known adversity to fish.

Parasites, Stadiums and Shelters

Early on this thesis attempted to find a relationship in the physical world that would help to imagine the combining of two different physical objects into one joined entity. Parasitic relationships provided numerous examples of creatures that would live off of one another, whether through leeching off a host or simply invading and feeding on a host. These relationships are always biased in one direction, but also maintain an equilibrium in the interest of survival to both the parasite and its host. The host is needed by the parasite to stay alive in many cases, and its eventual killing of the host would only put its own life in peril. The mechanisms at play to maintain this equilibrium are constantly shifting, taking a little away here and giving some back at another point. When this equilibrium falls out of balance, for whatever reason, both parasite and host usually face certain death.

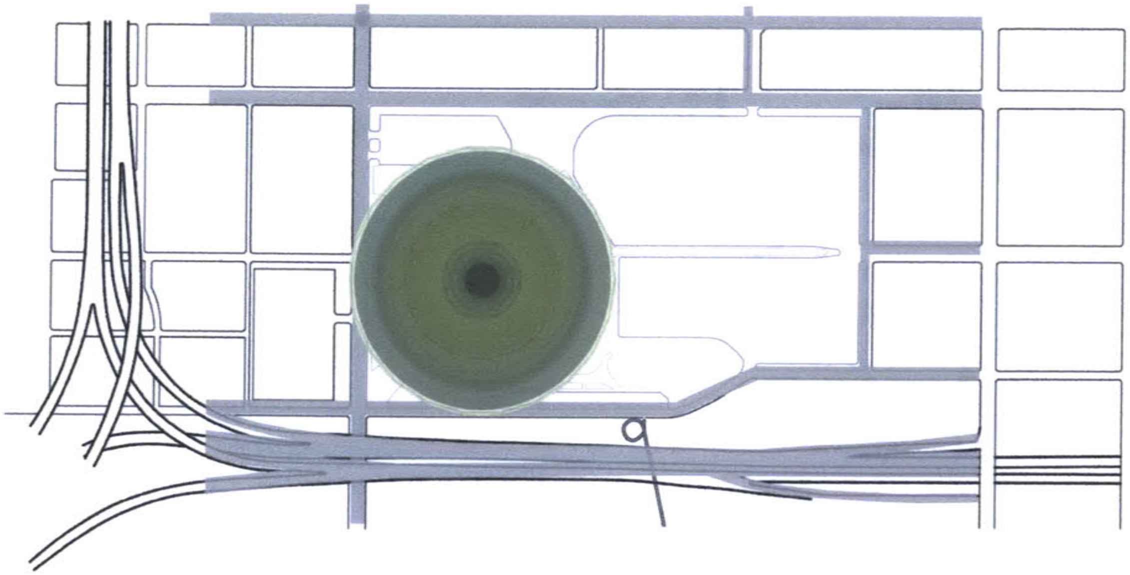
Recently a new parasite host relationship has been discovered that is particularly of interest to this thesis. A small crustacean has been found that is able to invade a host fish, attach itself to the fishes tongue, feed off the tongues main artery till the tongue atrophies at which point the crustacean assumes the role of the tongue and the two live together with no known harm to either creature. This is the first example of a creature invading another and assuming the role of a necessary body part. The two animals are physically tied together, each needing one another to survive once joined.

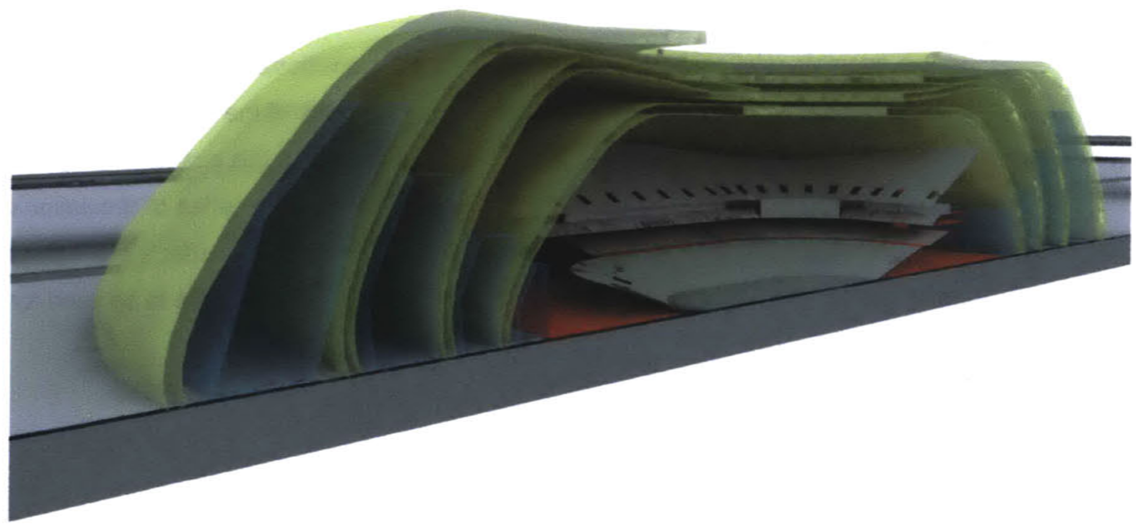
If stadium and shelter are to be combined into one piece of infrastructure within the city than it is vital that each be tied so tightly to the other that one cannot function without the other. The shelter must alter the stadium in such a way that it locks itself to both the internal function of the stadium and the structure that supports those functions. As the stadium is inevitably tied to the movement of people into and out of its central spaces the shelter parasite should engage that movement of people, and use it as the main element that it attempts to alter. The spaces of circulation become the main spaces of the shelter, feeding people through what will one day harbor them from an eminent threat.

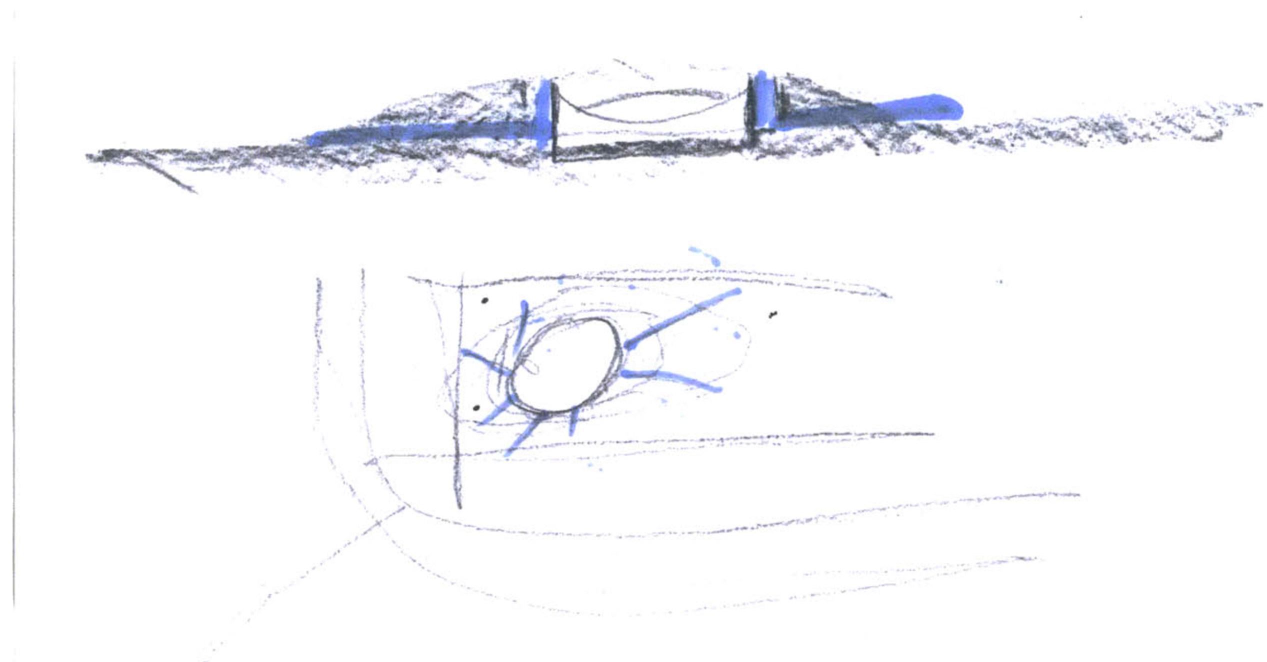


The Onion

In this possible relationship the shelter becomes a cocoon that closely wraps the area immediately surrounding the existing structure. The exterior of the structure is made up of a series of skins that together act to mediate the environmental conditions and forces exerted by a hurricane. Circulation spaces between the layers are both the main access paths to enter and exit the stadium, while also functioning as shelter space during a storm. The concept here is to absorb the influx of people through numerous entry points and circulate them between facade layers that act together to protect the core of the stadium from the effect of a hurricane. The problem with this relationship is that it is limited to the area immediately surrounding the stadium and does not attempt to engage the larger context of the site.

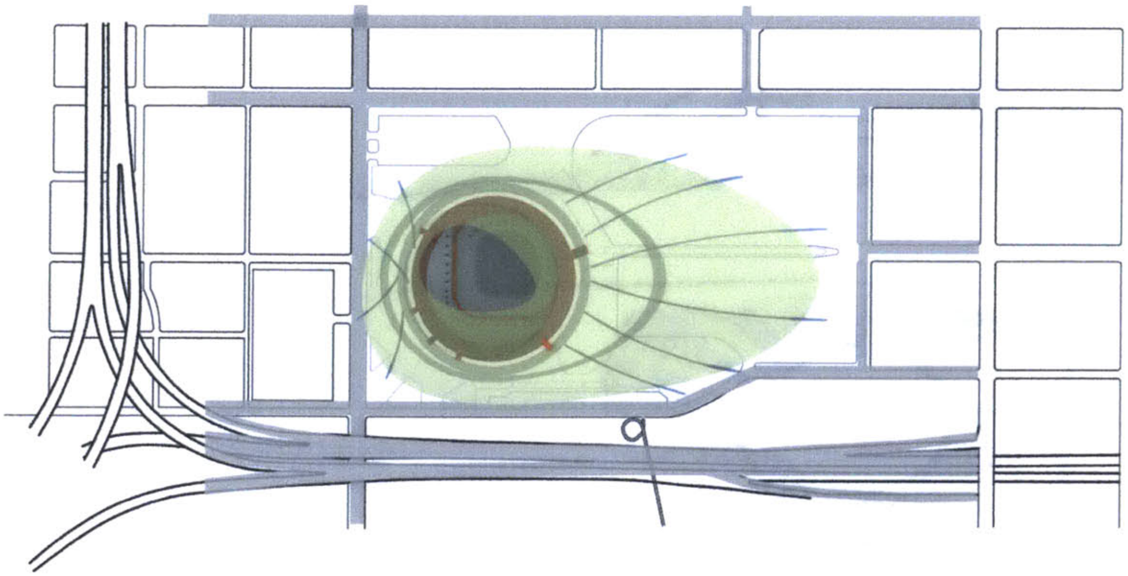


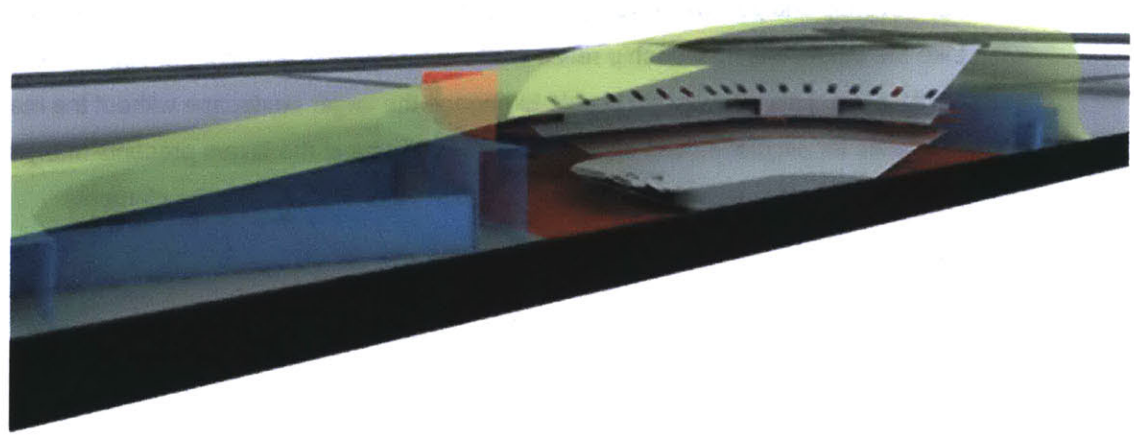


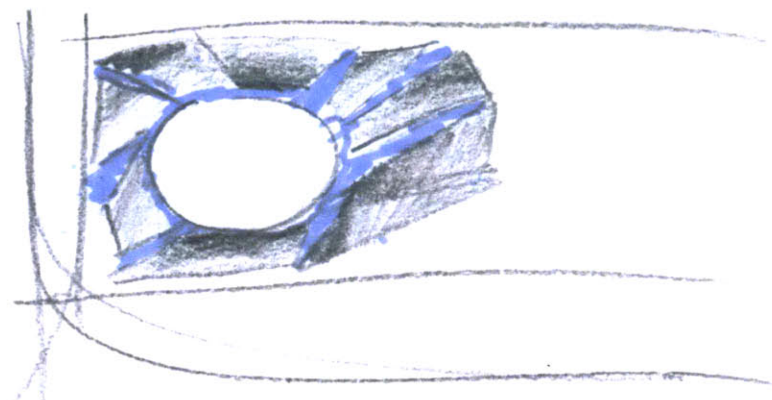


The Berm

In this possible relationship the shelter becomes a transitional landscape that slowly rises from the larger context to the height of the stadium. It provides protection by deflecting the forces of the hurricane slowly up and over the stadium. It presents no vertical walls or surfaces. There is no layering of facade elements in this example. Only one clean surfaces is presented to the outside environment under which the spaces of the shelter interact with a series of circulation corridors that bring people from the site into the stadium. While this relationship provides great protection from the effects of a hurricane it provides little interaction with the environment. It also renders large portions of the site impassable and unable to be used for parking.

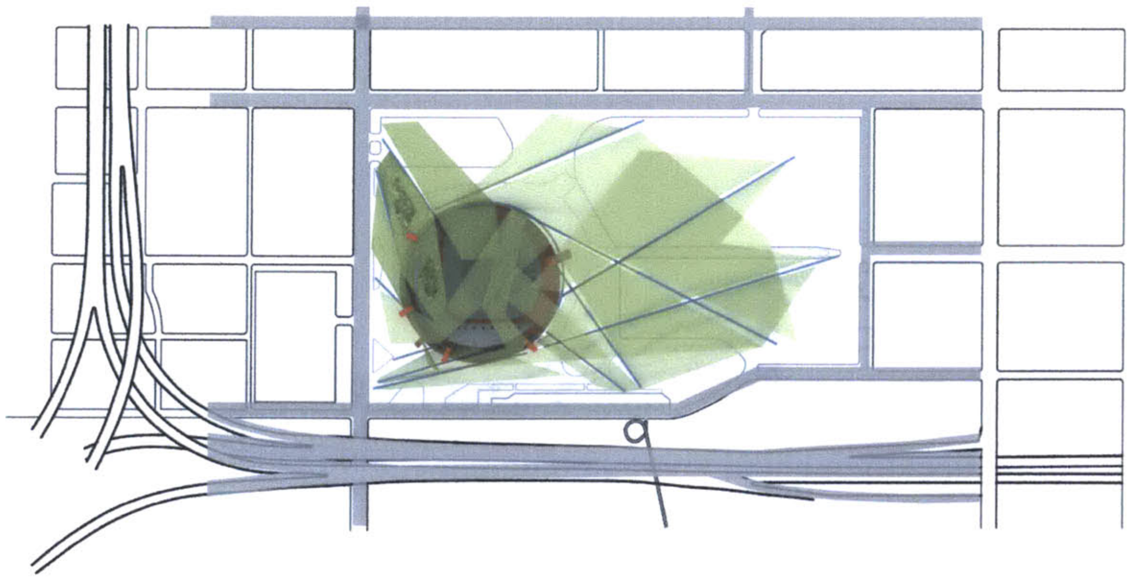


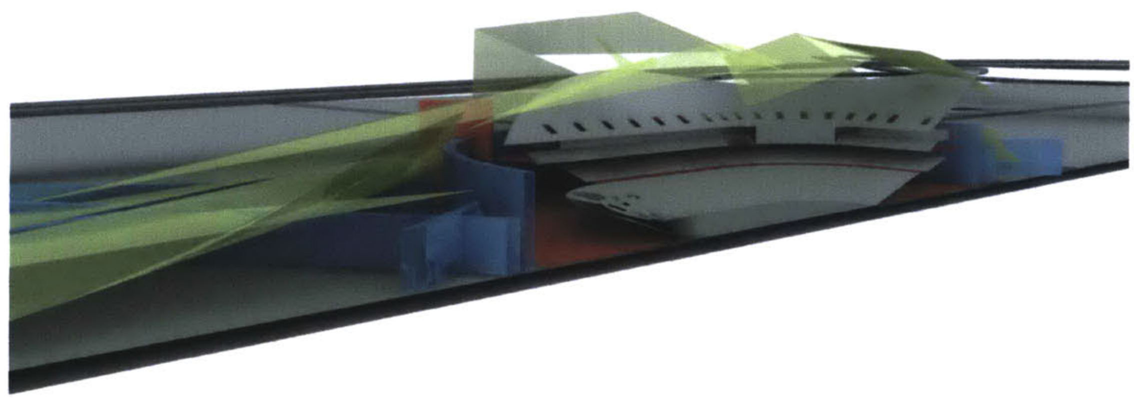


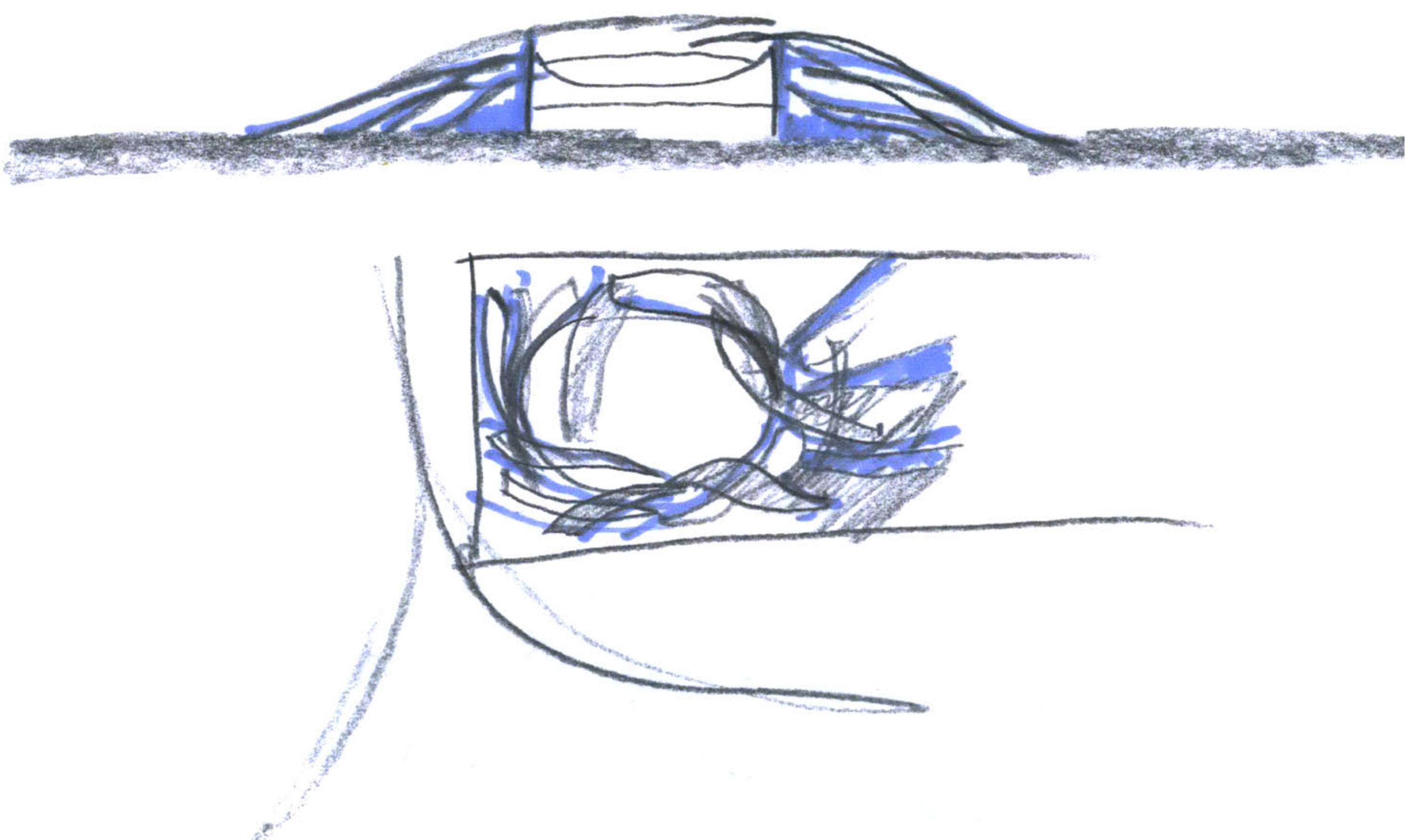


The Fracture

In this possible relationship the shelter becomes a series of planar elements which fold up from the landscape. These elements intersect, overlap and peel away from one another creating a series of spaces within which circulation and shelter spaces can take place. Like the onion, this relationship relies on the interaction of elements to deflect the effects of a storm away from the core spaces of the stadium. This relationship is able to engage the larger landscape without the massiveness of the berm, but lacks in a continuity of spaces for circulation and sheltering. The fracturing of the layers presents many opportunities for engaging the environment and has the greatest possibility to create intersecting spaces between the elements.







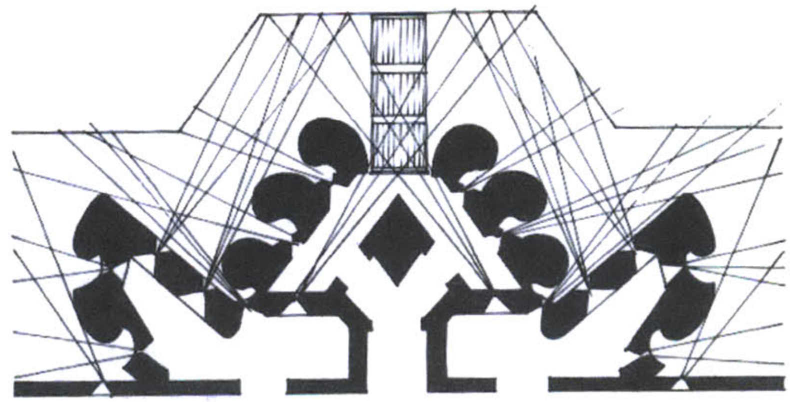
The Hybrid

In the end no single relationship provided enough possibility to create an effective relationship between stadium and shelter. This hybrid example looks at the strengths of each diagram and ties them together into one functional relationship. In the end, the most important element that came from these studies was the need for the shelter parasite not to be a singular entity but to engage the larger context of the site.

When we think about trying to deflect the massive forces imposed on a structure during a hurricane it seems logical to create a facade made up of multiple layers. The layers act together to absorb the effects of the storm by passing wind and rain through differentiating layers that each mitigate some of the storms intensity. These layers can than become filters for light and air after the storm so the spaces of the shelter do not become dark and stagnant. Instead of presenting the storm a wall, the new shelter presents it with a soft facade that absorbs versus deflecting.

Engaging the larger context of the site is important beyond extending the protection of the shelter into the landscape. Recovering some of the vast asphalt parking lot into spaces for recreation, aid disbursement and staging of aid increases the appeal of the shelter as a place that isn't confined to the indoors. The shelter becomes a blurred boundary between the internal core of the stadium and the larger context within which it sits. The outside environment becomes just as important to the functioning of the shelter as the spaces within its concrete walls.

Michelangelo Sketch of Soldiers Fighting
Domeyko Slide Collection



Design for fortifications; after Michelangelo.

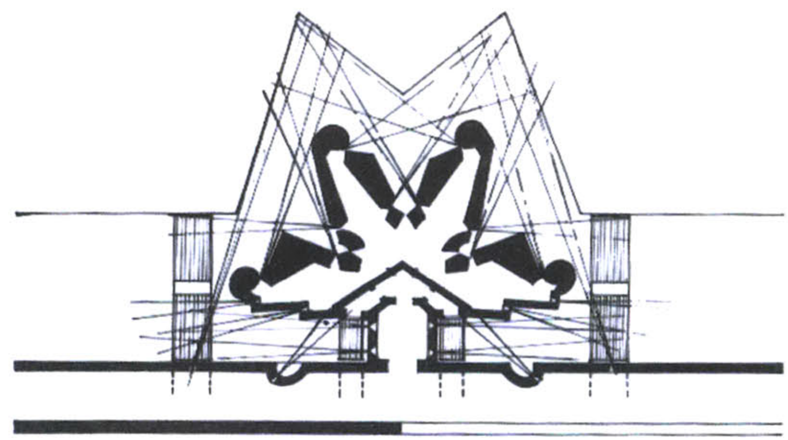


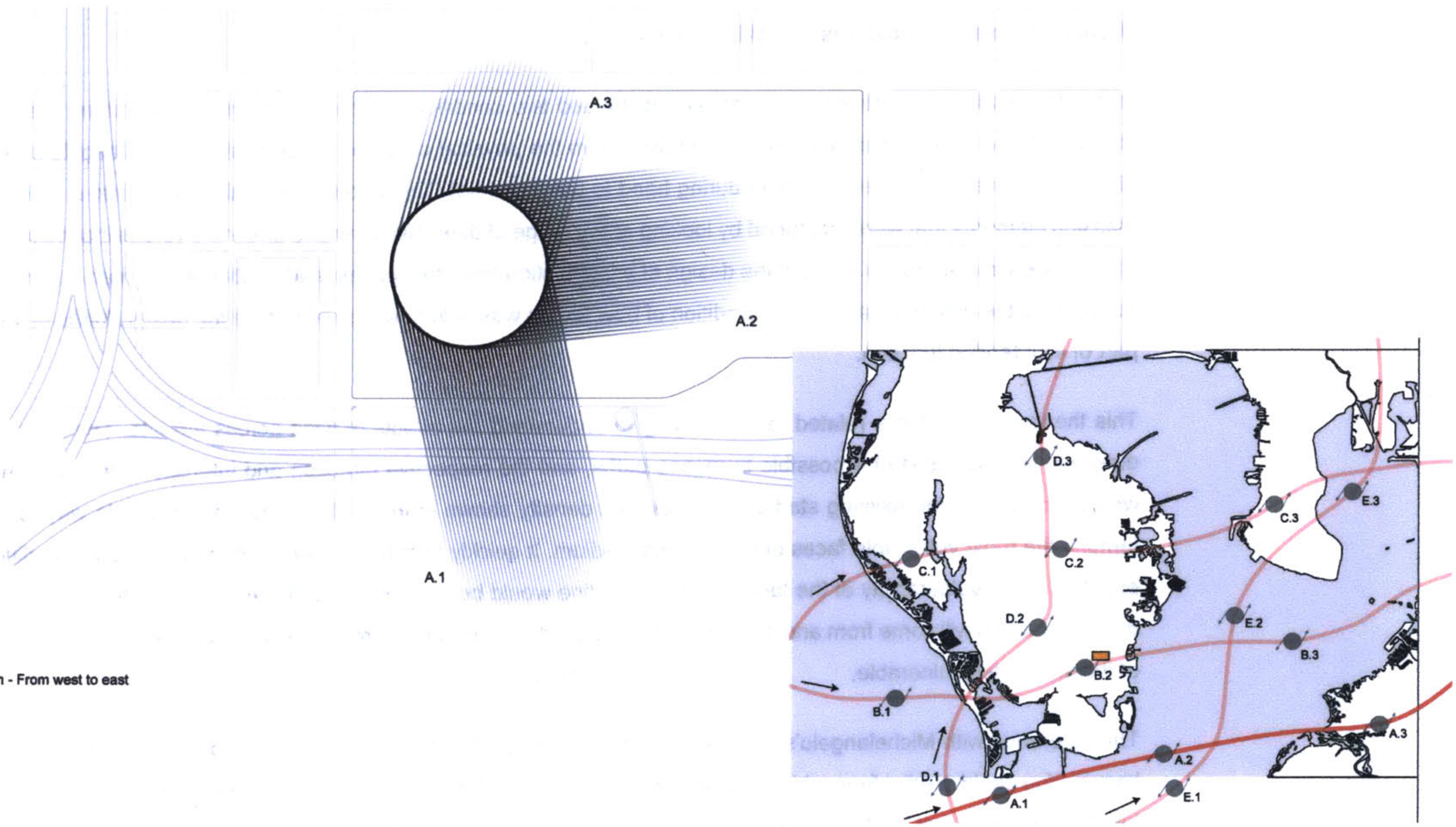
Diagram of Michelangelo bow and arrow fire
Domeyko Slide Collection

Michelangelo's Fortifications and Wind Fields

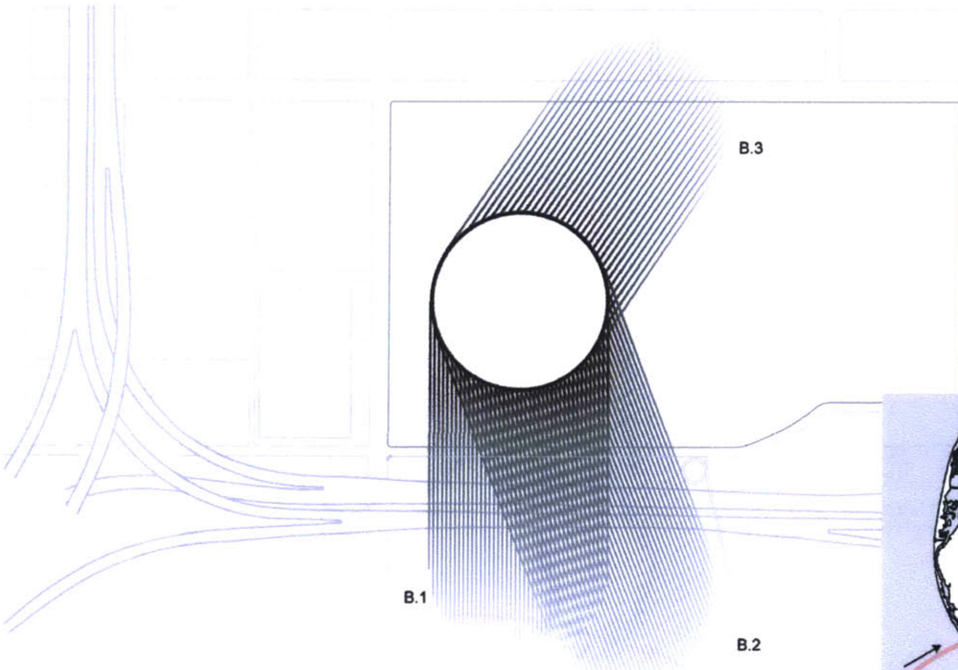
In his designs for fortifications, Michelangelo abstracted two conditions that allowed him to understand the best forms for these defensive structures. Far removed from the physical condition of fortification Michelangelo looked at the forms created between soldiers during hand to hand combat. These forms were abstracted into a series of massing elements that were fine tuned by looking at the range of defensive bow and arrow fire versus incoming fire. At first look it is a stretch to abstract the design of a fortification from the spaces made between two men in combat, but by tying the outcome back to the condition of bow fire he was able to effectively prove the design fulfills at least part of its intended function.

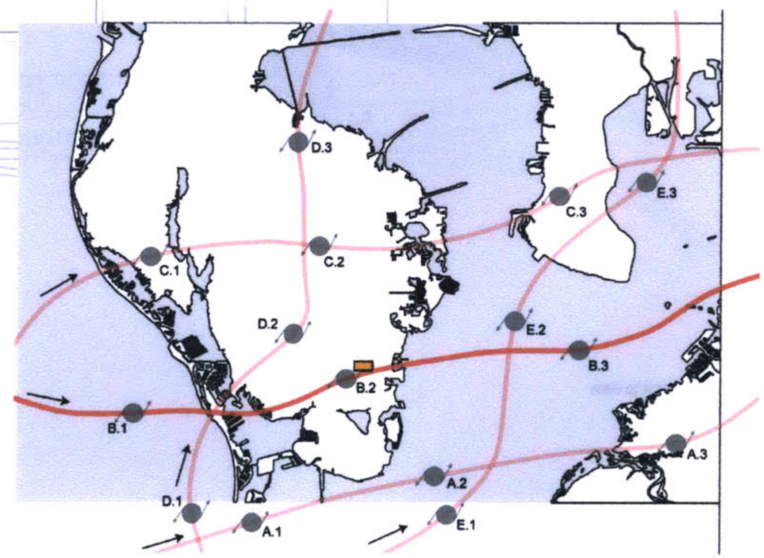
This thesis investigated a related tactic in trying to understand the effects of wind across the site. The following drawings are the result of 4 possible hurricane paths, and the respective direction and intensity of the wind they would produce on the existing stadium. The layered density shown in these diagrams are a possible way to determine the most vulnerable faces of the existing stadium. It quickly became evident that there would be no differentiation in the vulnerability of the faces once this routine would be run 100 times. There is no way to predict what direction storms will come from and if it were to be designed to a statistical threat direction then there would be parts of the shelter left vulnerable.

The difference with Michelangelo's fortifications and that of the WWII bunkers is that the direction of the threat is known. You could predict from which direction the impact of the threat would come from and thus design the structure to respond to that. In the case of the hurricane shelter this is not an option. The shelter must be prepared for a threat from any direction.

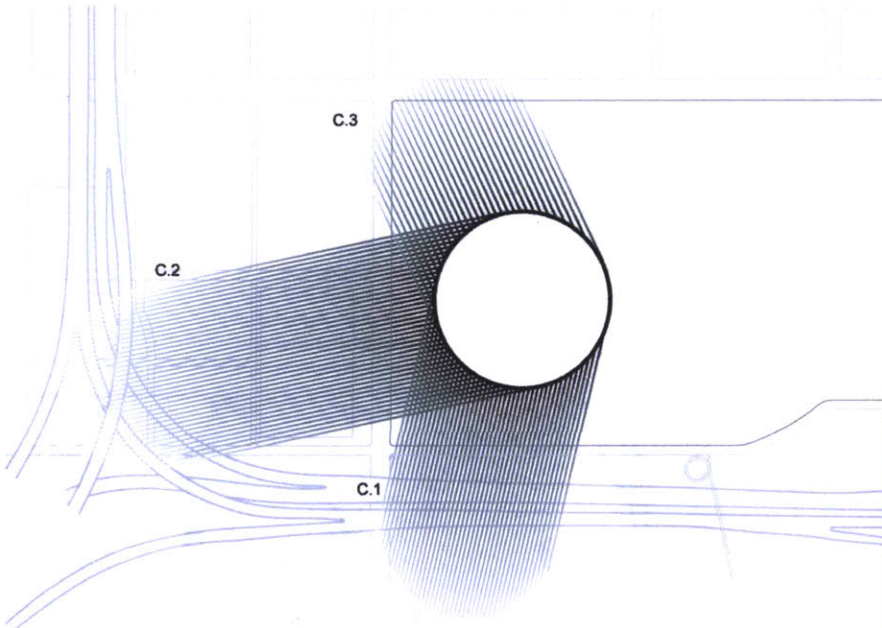


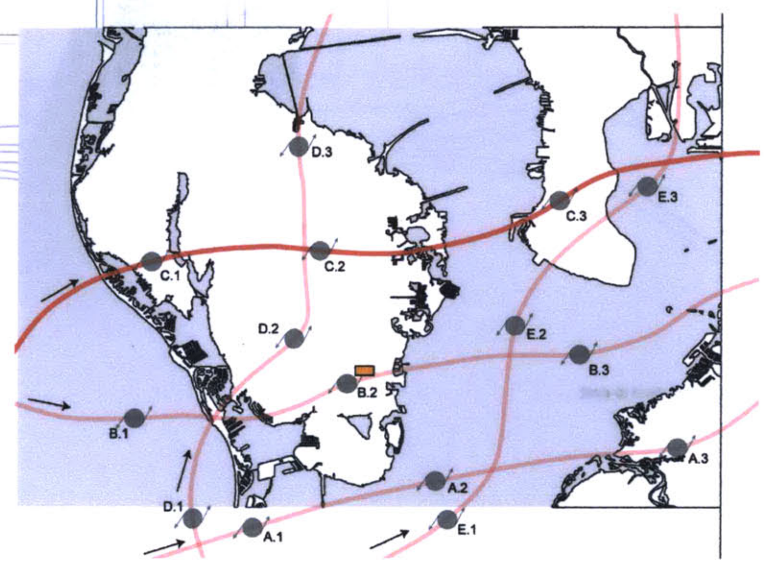
South - From west to east



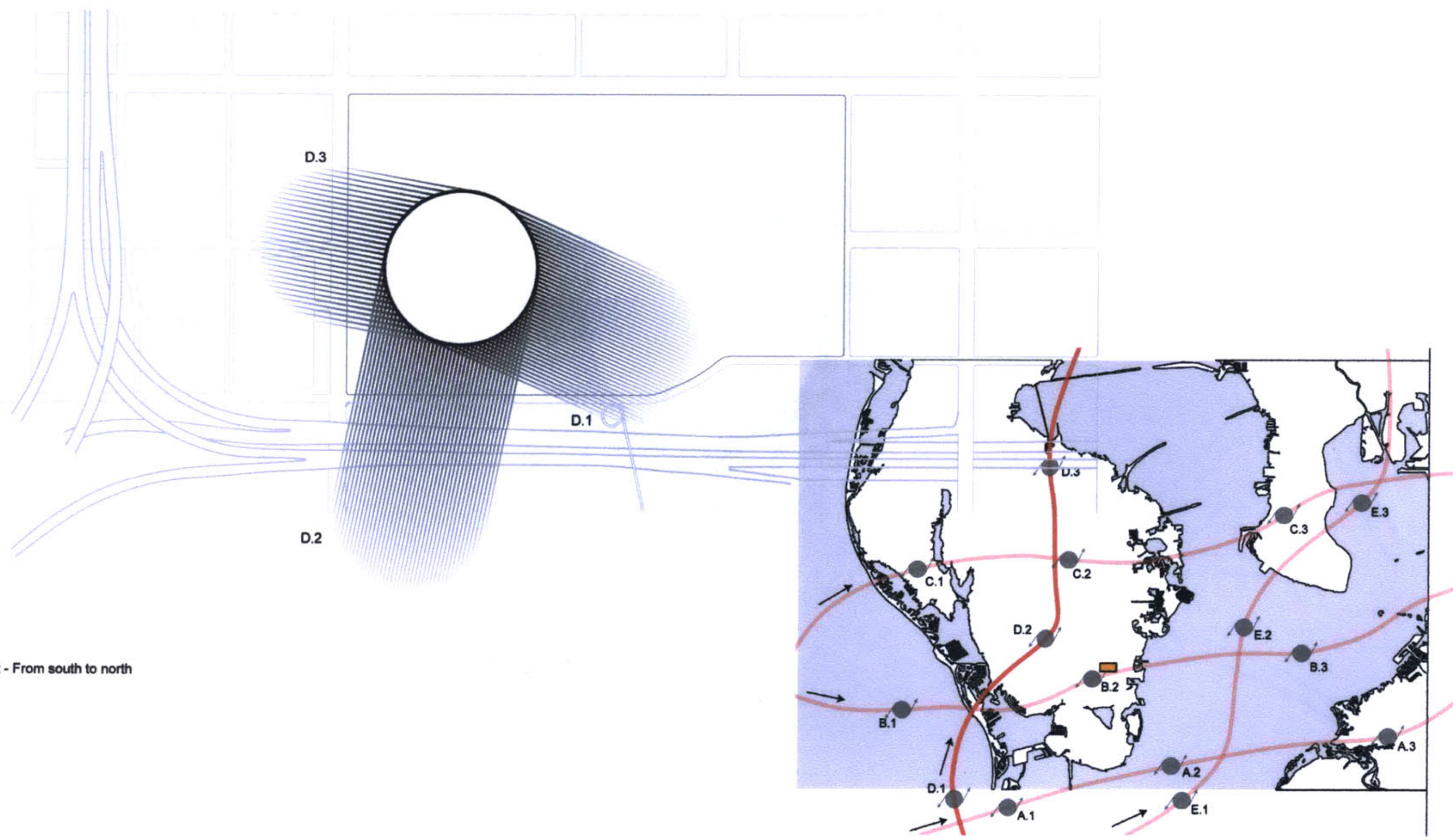


Central - From west to east

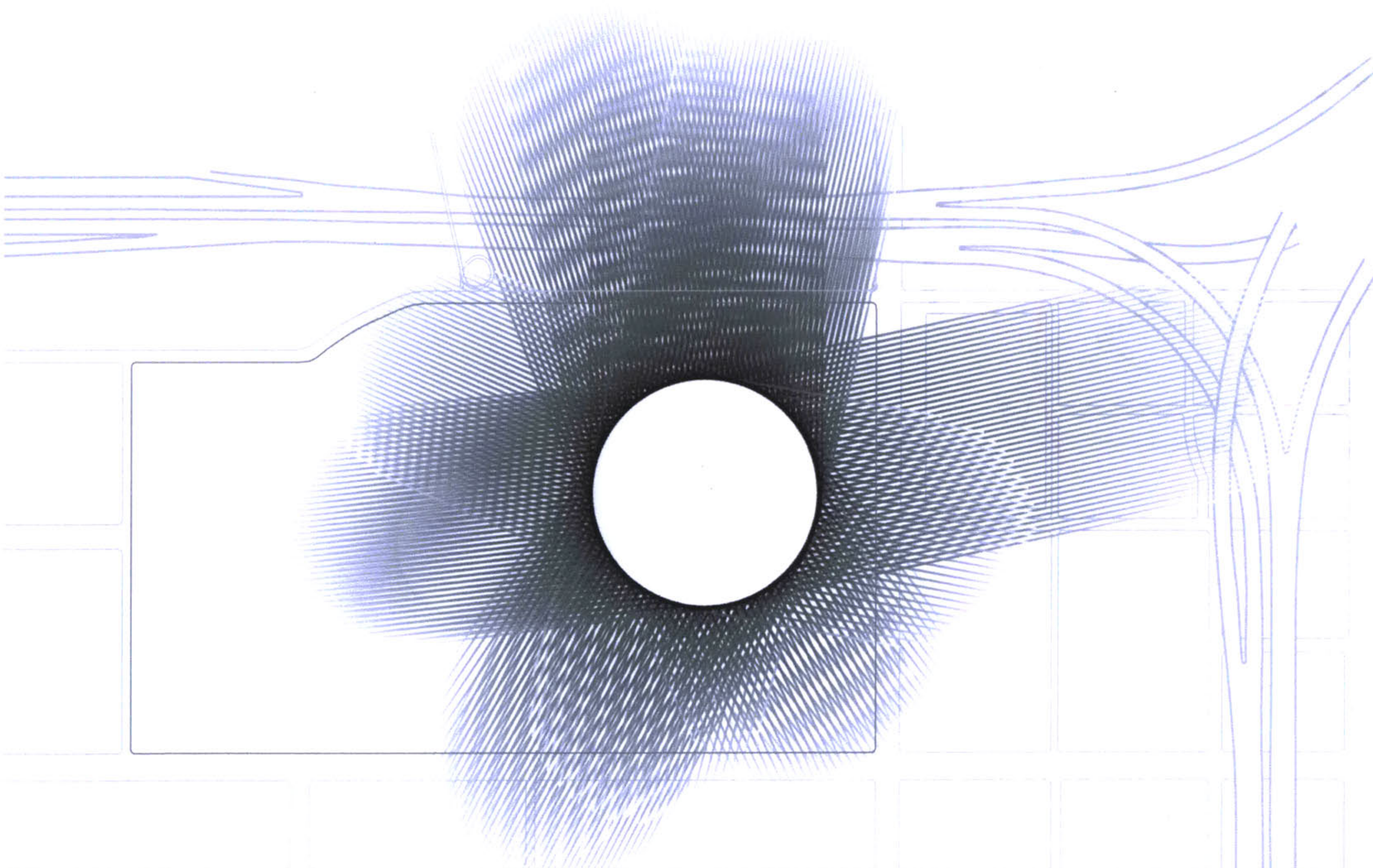




North - From west to east



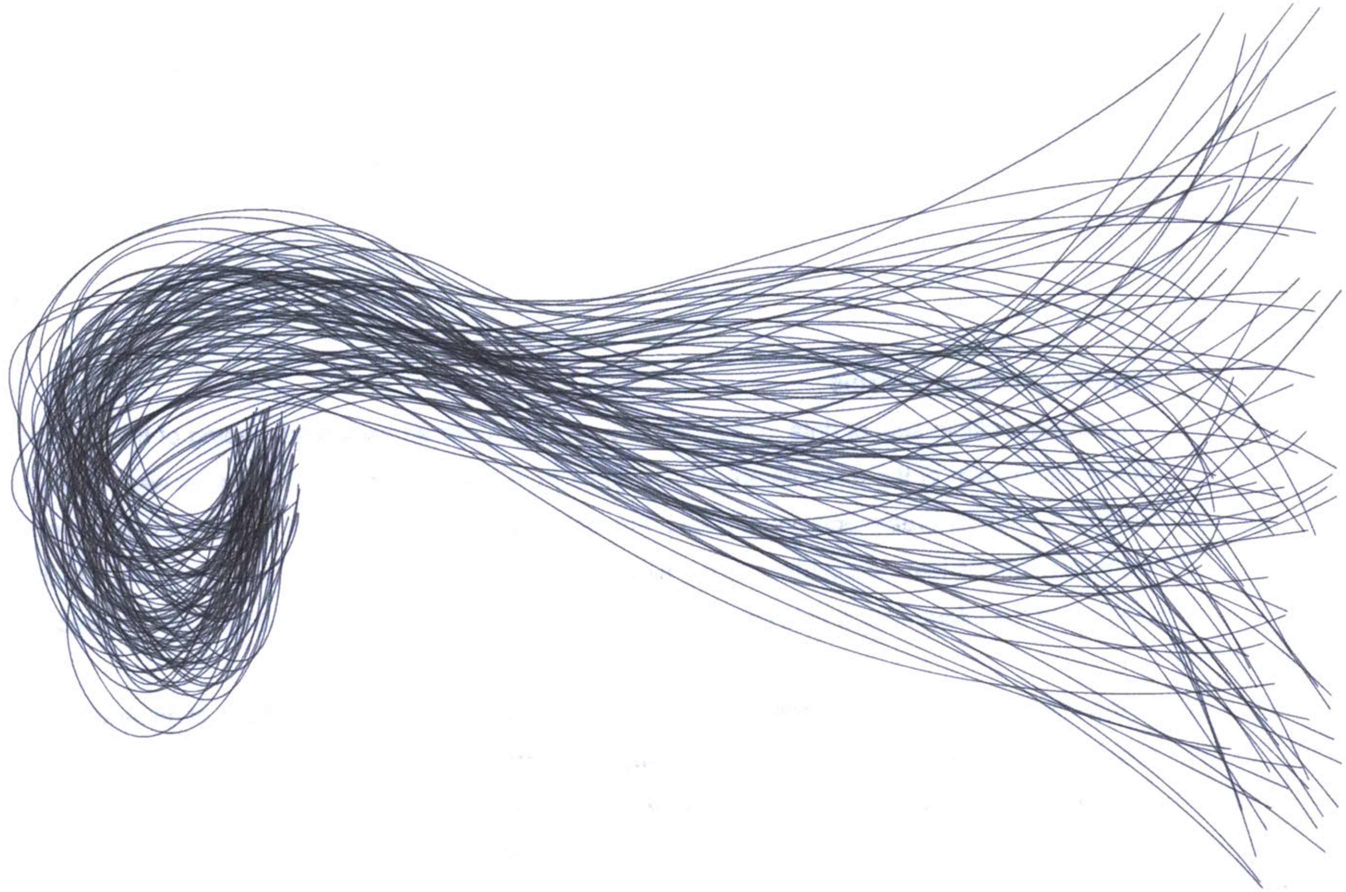
West - From south to north



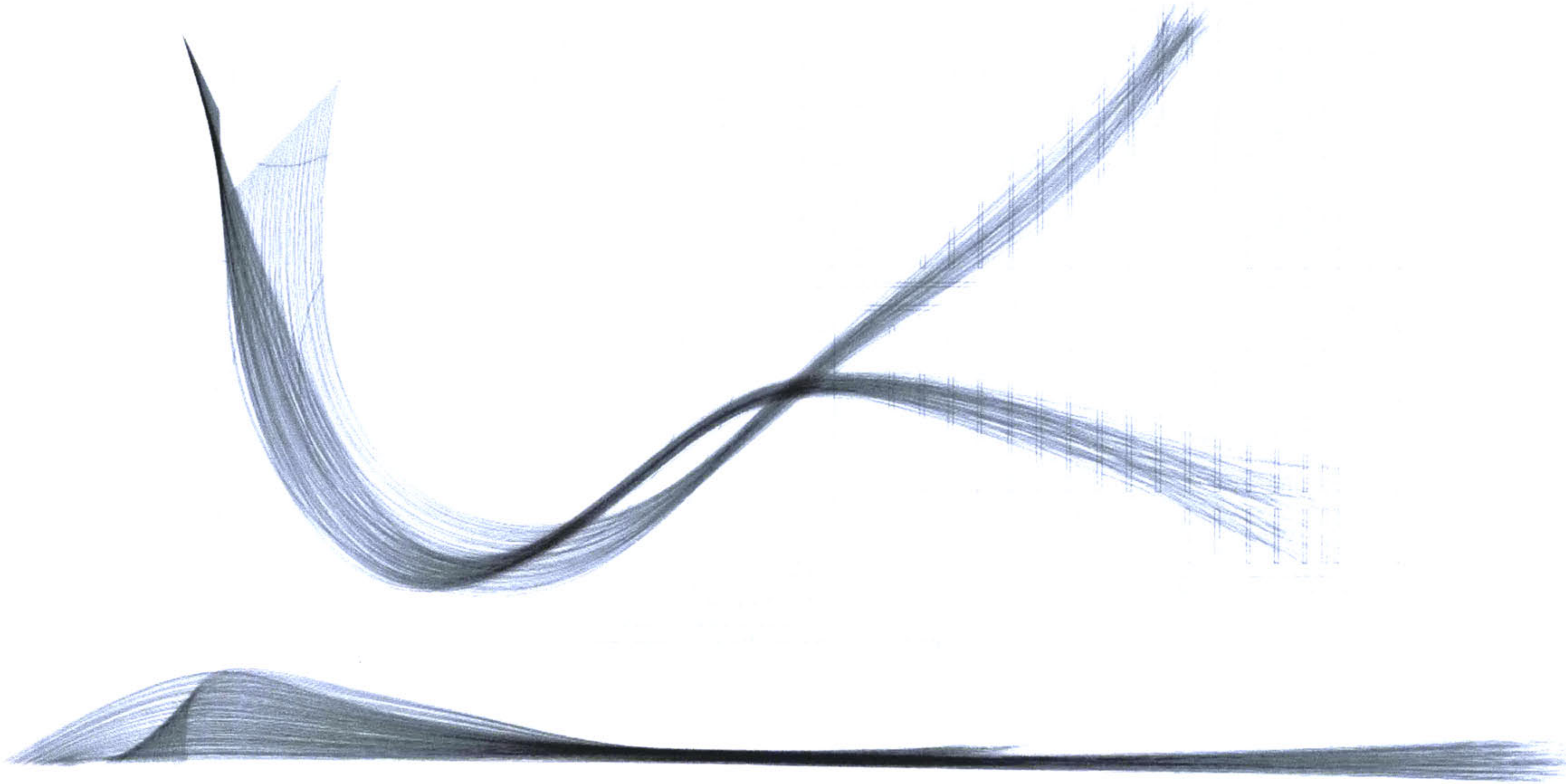
Layering Paths over Paths

Overlaying multiple sets of data in the form of paths produces an additional reading of the original information. In this drawing each of the three sampled wind fields from the four possible hurricanes were overlaid on top of one another to look for areas receiving the least amount of wind. The result isn't interesting in terms of what face of the stadium might be least susceptible to the highest winds, but it is interesting in terms of the densities produced. In overlaying the information a field condition is created within which spatial conditions can be read.

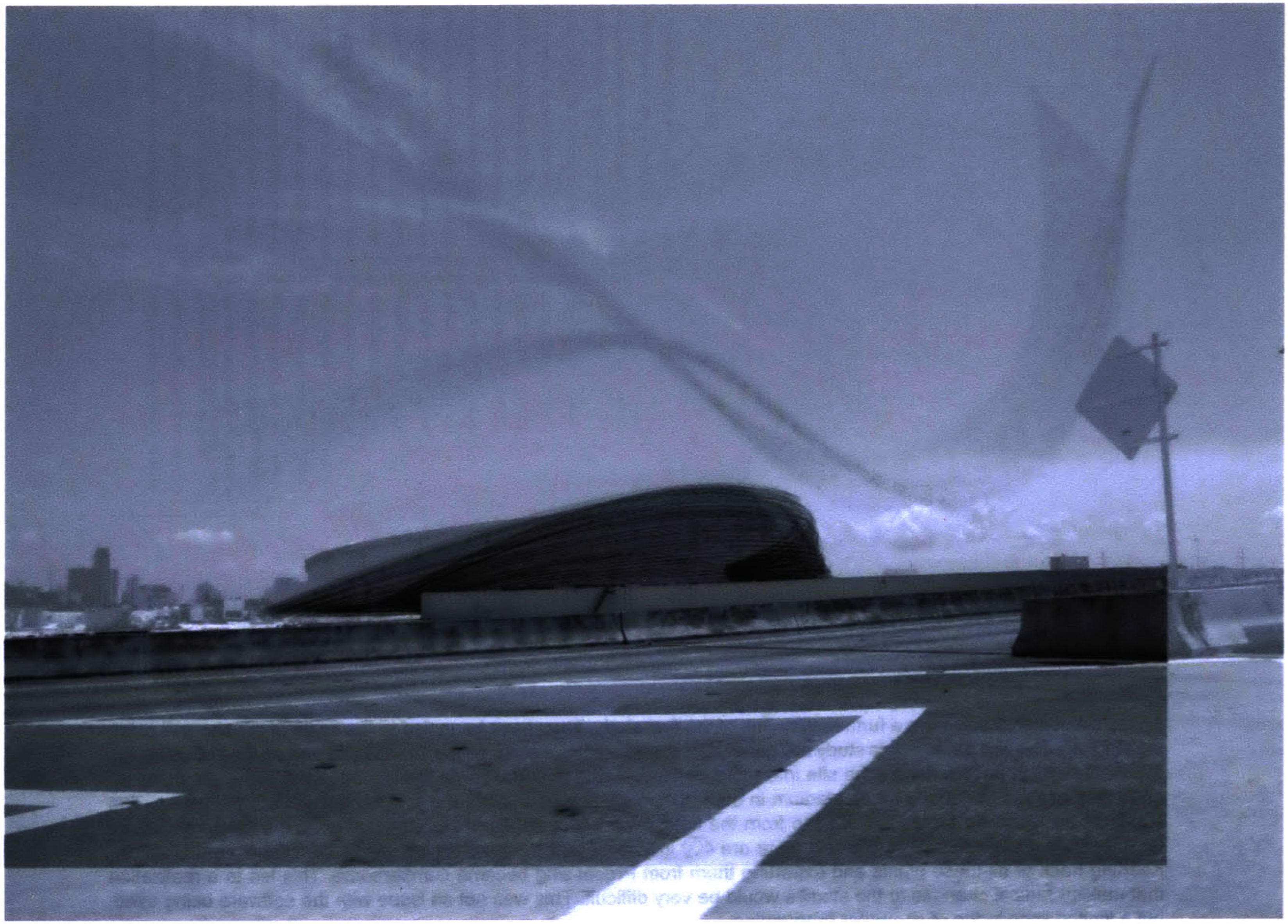
In the following studies this condition of layering is applied to a more robust system of generating paths that contain real 3-D geometry. In this diagram the only way to extract spatial conditions would be to abstract a 2-D drawing into 3-D geometry based on density, overlap, or void. In the following diagrams the same process could be used, except there is also usable 3-D geometry already imbedded in the diagram.



This first attempt at generating, through a program based environment, a series of possible paths a pedestrian might take into a stadium. In this diagram hundreds of random pedestrian paths are overlapping and layering upon one another around a core. The idea is to abstract the circulation of people across the site and into the stadium as the generator for the form of the shelter. The geometry in this diagram was produced in Processing, a powerful JAVA based programing environment. This simple code produces paths from random start points and passes them through 5 control points as bspline curves. The control points move randomly within a set range producing the "walking" effects of the individual paths. Geometry was then exported from Processing and brought in Adobe Illustrator where the lines were given some level of transparency in order to begin to see more or less intense areas of layering. This diagram was successful in testing the method, but wasn't constrained to any of the site conditions and as such the result is devoid of a context.



These circulation studies are a further evolution of the first study. They have been tied to the scale of the site and existing stadium. The two paths in this study are generated based on major entry points into the site and an idea of collecting the movement of people across the site into more defined spatial boundaries. In the elevation the paths are rising up once they engage the space of the stadium in order to provide the beginning of a layered tensile facade system. The elements are seen as cables which wrap from the landscape into a series of facades that wrap the existing stadium like a cocoon. In this particular example there are 400 individual paths each of which has its own set of control points. Keeping track of all these points and exporting them from Processing became cumbersome. This led to a realization that making radical changes to the studies would be very difficult. This was not an issue with the software being used, but a limited knowledge of computer programing.



Soft Facade V1

A final outcome of the studies using Processing to generate pedestrian paths was the image to the left. It represents a lasting image for this thesis that informed the way the project would move forward. It became evident that the shelter needed to engage the existing structure in a way that responded to its function and the protection it needed to provide.

The idea of the soft facade came into being by imagining a facade system that could be flexible to forces coming from unpredictable directions, but also be a filter to the environmental conditions allowing light and air to pass through. In this image the facade is imagined to be cables that engage a series of new structural elements attached back to the existing stadium. The spaces between the facade layers become circulation corridors that double as shelter space during a storm. Each layer of facade is able to absorb some amount of the storms impact by slowing winds, catching debris and reducing the amount of rain getting through.

From this study a physical model was constructed that showed how the individual facade layers would engage the larger context of the site. In the area of the site that is a parking lot the elements moved from vertical surfaces to the horizontal surfaces that provide protection to parking garage structures. The tensile elements were to provide protection across the entire site.

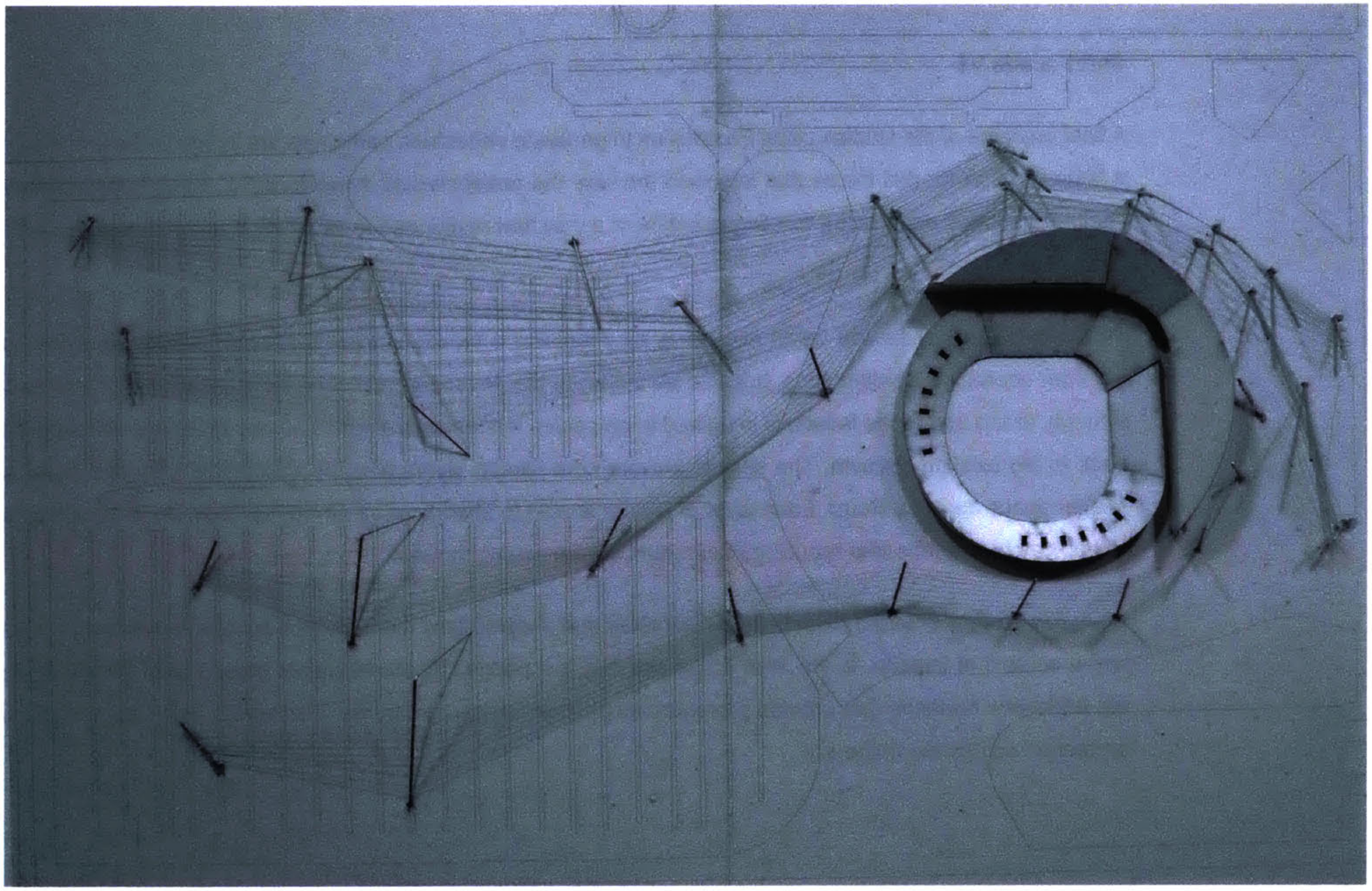
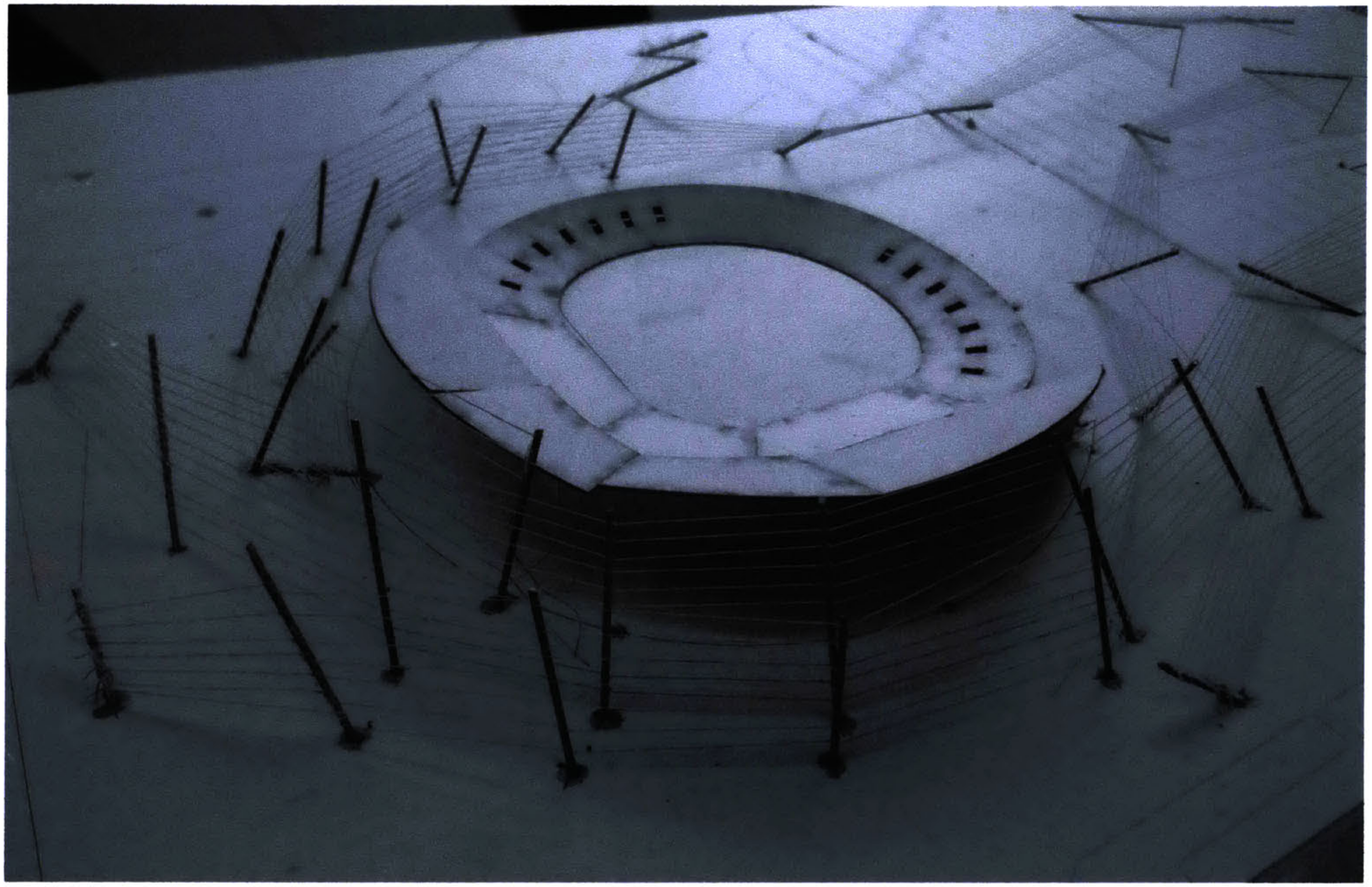
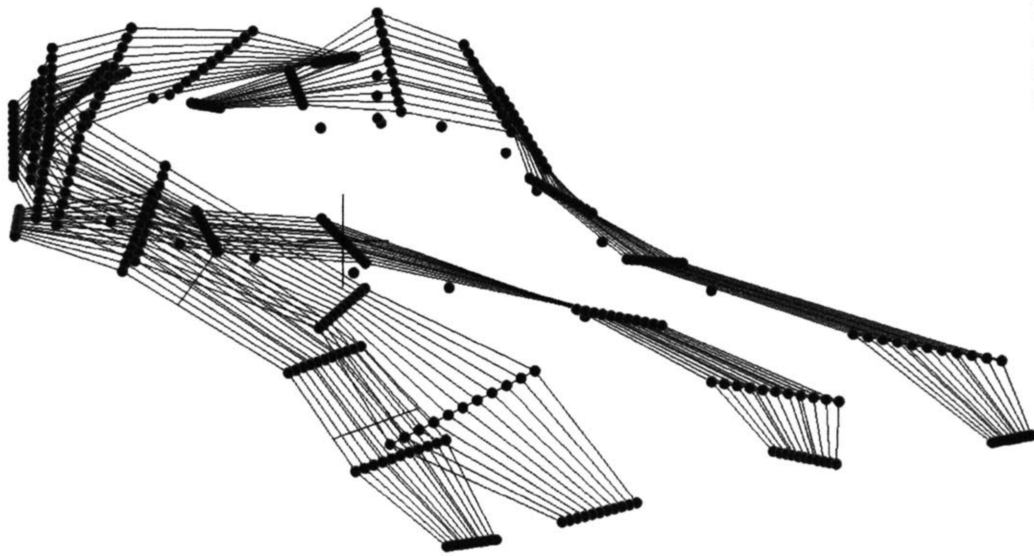


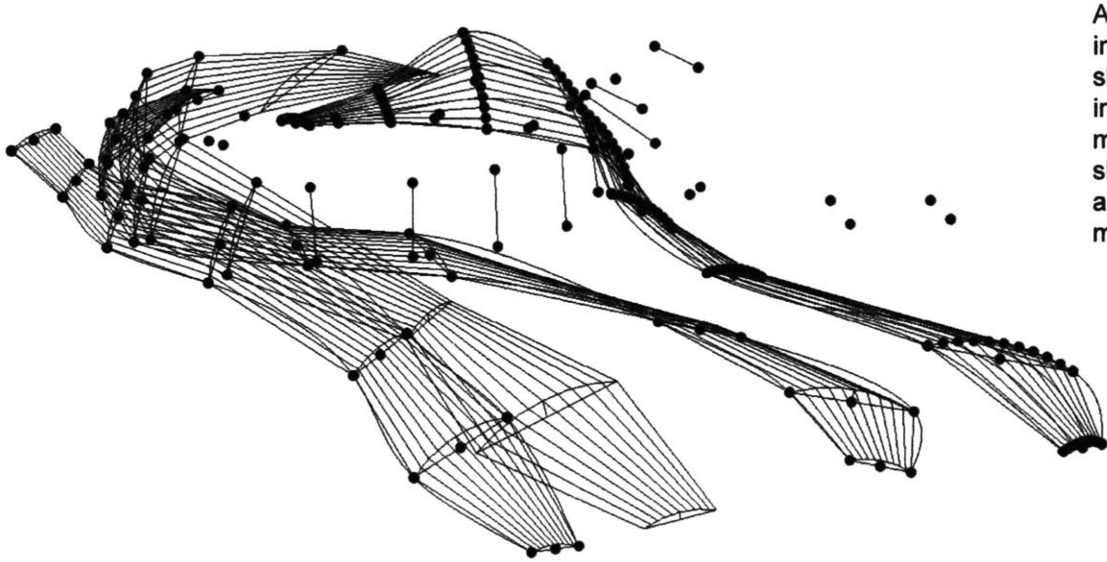
Image of the first physical study of the tensile facade elements. The number of layers increased on the back of the stadium as this area has the highest density of shelter space.



The model in perspective showing the scale of the facade elements as they begin to wrap the stadium.



Physical model adapted to Generative Components. The inputs are fixed points in space, but are tied to the scale of the site. The only adjustable feature is the number of cables making up the facade



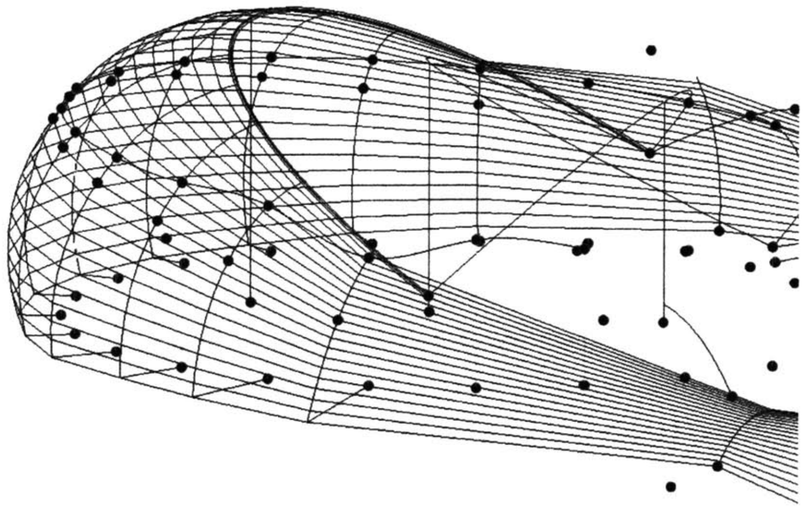
Acrs are added as the main structure for supporting the cable facade. This adds stiffness to the shape of the structure and will help prevent buffeting during high winds. Again the number of cables making up the facade are adjustable along with the shape and height of the arcs. These adjustments are made globally and tied to the span the arcs are making.

Parametric Model: Adapting Facade to a Structural Shape

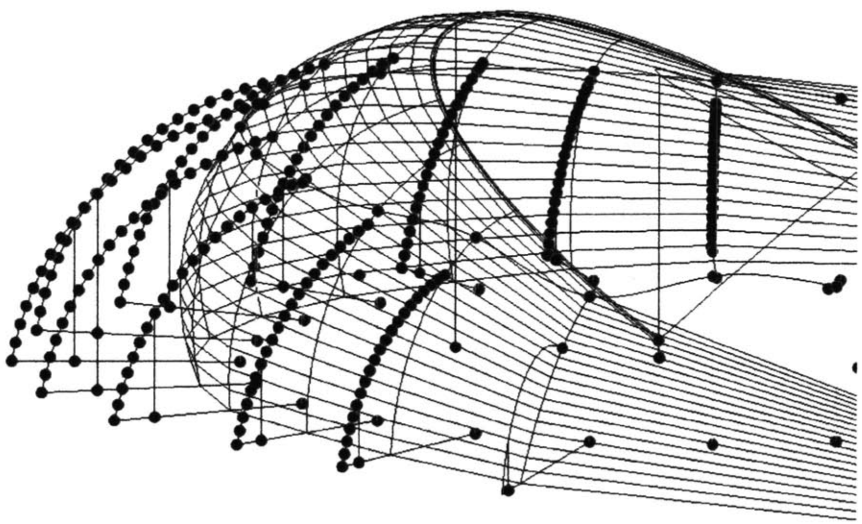
After the physical model was constructed its geometry was transferred into Generative Components and rebuilt as a base to further develop the facade structure. In the physical model the main struts of the structure were straight and linear. While this provided visually appealing tensile elements, the flatness of the shape would not have functioned very well in high winds. A series of model iterations were created that added curvature into the structure of the facade. This curvature would give the tensile elements stiffness in the event of winds to prevent buffeting and vibration.

A series of new elements were also added to the existing model increasing the number of facade elements to six. Each was engaging specific areas of the site in order to engage the different types of entry into the site and existing stadium. Longer elements wrapped back into the existing parking area in order to provide full enclosure across the site for people arriving by car, while shorter elements engaged the front of the site in order to catch pedestrian arrival.

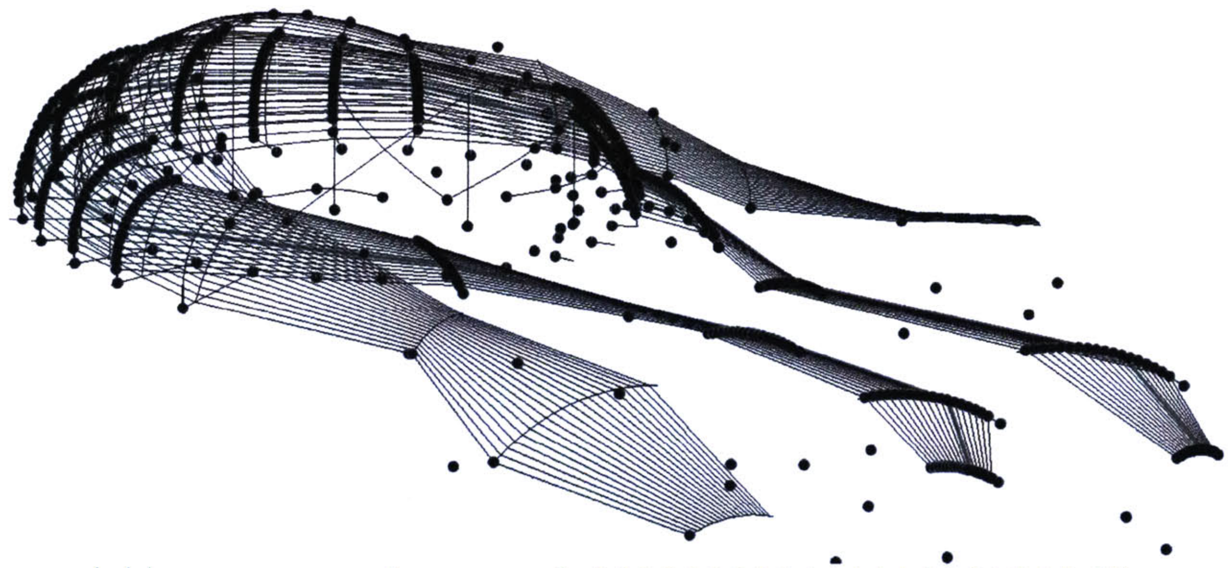
In the final evolution of the model the facade elements began to wrap into the roof of the stadium. The number of facade elements decreased back to four and only three engaged the larger context of the site. The structure of the facade was tied directly back to the existing structure of the stadium and to a large extent the initial ideas of the tensile facade started to disappear. It became evident that this model was not effective at keeping the idea of a tensile facade. As the model became more interested in buttressing structural elements and proper shapes for arch's spanning the roof the earlier ideas of the project began to disappear.



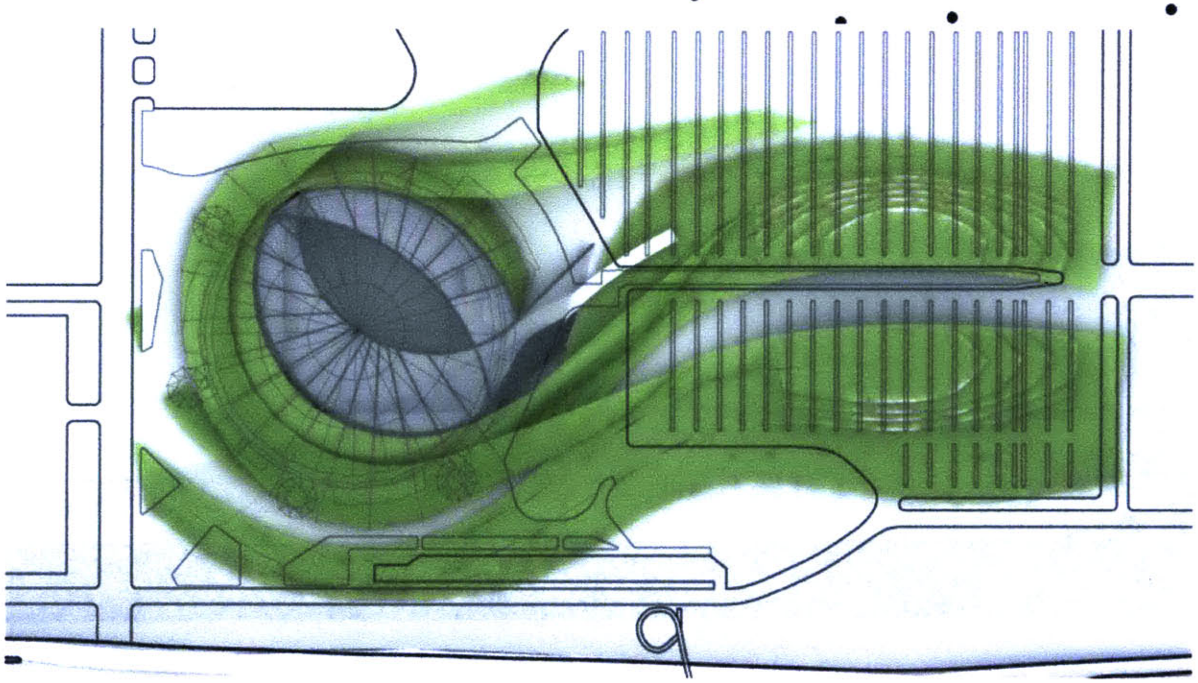
The facade begins to wrap higher up the existing stadium becoming part of the roof. A series of arch's begin to span the roof forming the structure of the new roof. The location of the structural elements are now fixed in relation to the existing 24 structural columns of the stadium. Each is projected perpendicular to the circle of the stadium. Each structural element is tied globally to one another and is individually adjustable for curvature. Each element is also tied to a new arch that is one of two main supports for the roof.



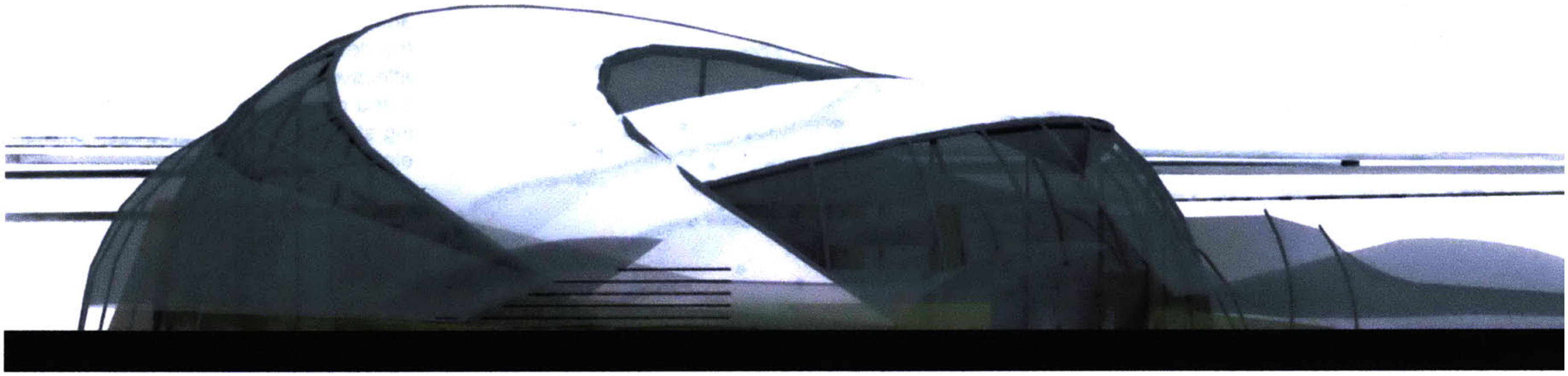
The structure for the second layer of the facade becomes a series of buttresses to the main structure. This notionally would increase the stiffness of the whole structure. Each of these elements falls in plane with the other structural pieces. They are adjusted globally for the height at which they engage the first layers structure, but individually for curvature and space between the two layers of facade at the ground level.



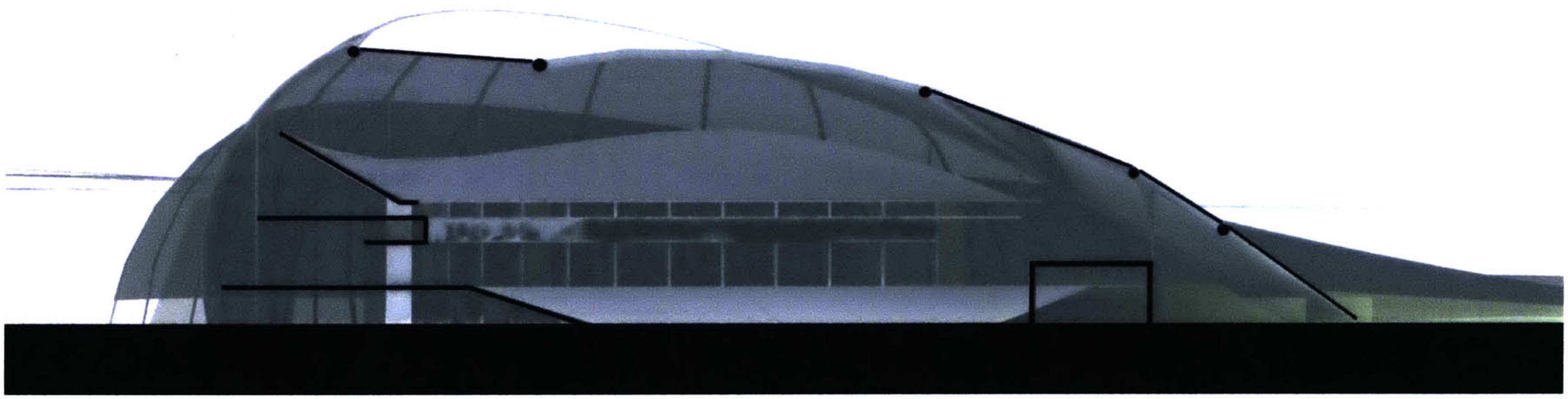
This image of the final model shows that the initial form of the physical model was closely maintained. This was caused by a lack of early investment into creating inputs that could easily adapt and change the overall form of the design. The model in the end was effective at working through complicated relationships between the existing structure and the proposed shelter elements.

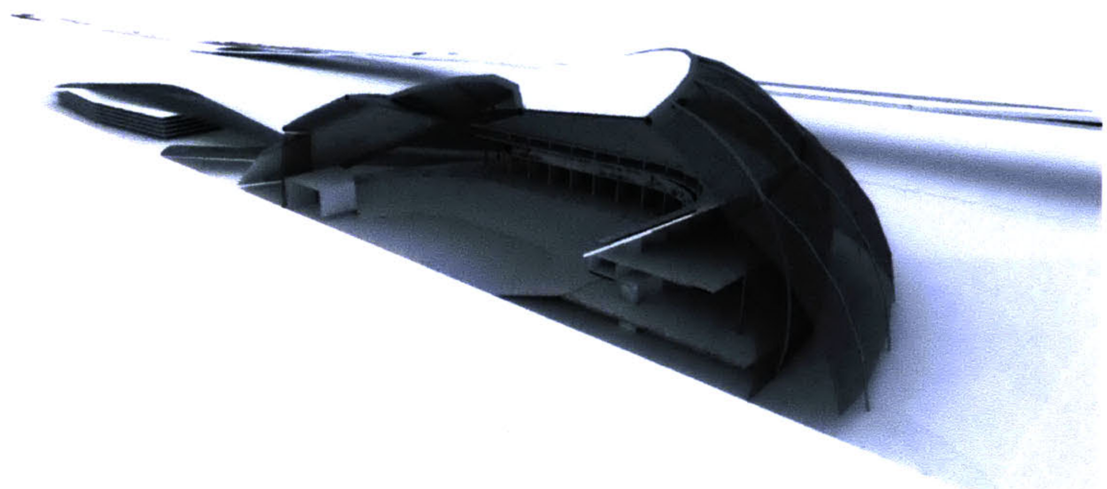


This is the last plan adapted from the model above. As much as this project was making the point that the forces from a hurricane are not predictable or directional, this has an obvious directionality. The layering is now masked behind surfaces and has lost the soft quality of the starting image. The model became to interested in solving geometric relationships between structural elements and didn't engage the larger ideas of the project.



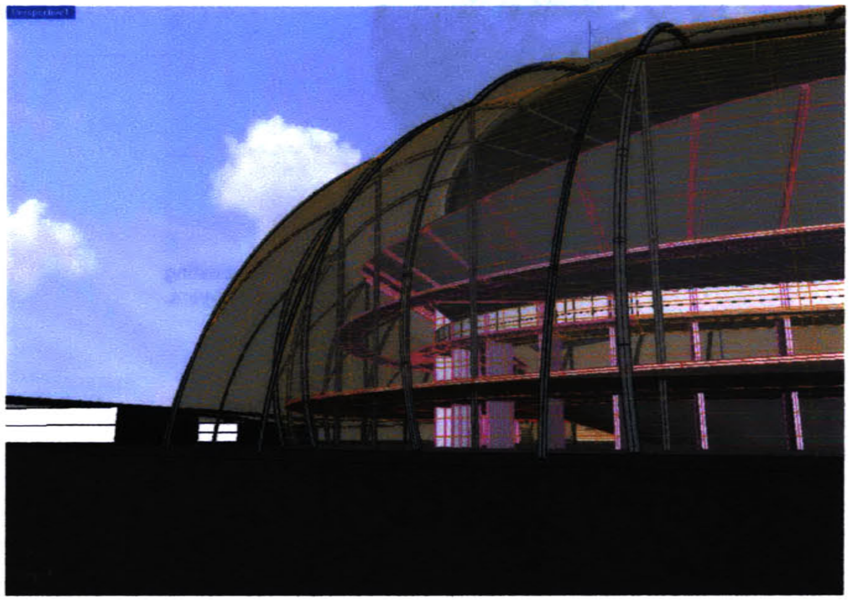
A section taken through the parking garage.



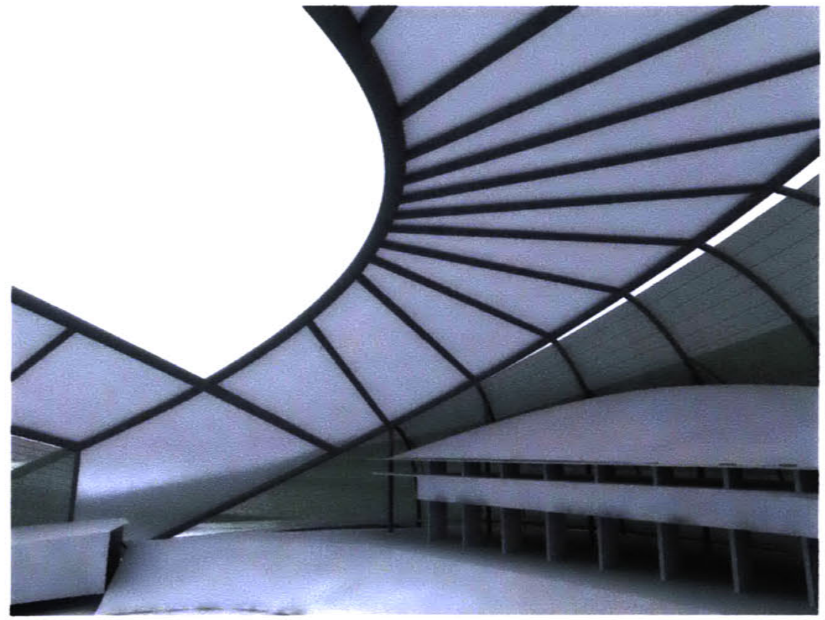


This section model shows the relationship of the existing stadium to the facade layers.

A section cut the complete length of the site.



A view from the front of the stadium. The facades have been reduced to two surfaces.

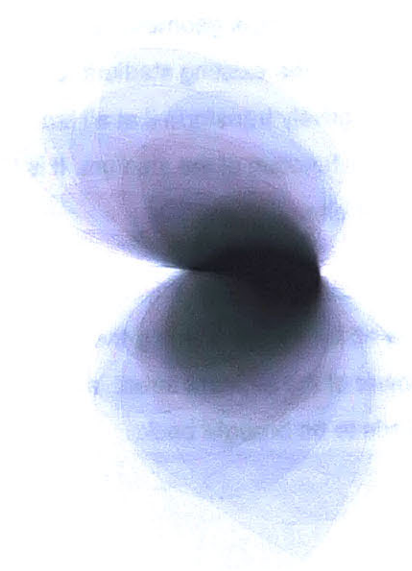


A perspective taken from within the seating area of the stadium showing the new roof structure

Failures of Soft Facade 1: Rational solution to a irrational threat

This thesis needs to propose a radical solution to the form and function of the shelter. The early study showed that to effectively function as a civic apparatus the shelter needs to engage the community both functionally and visually. It needs to present itself as such a radical departure from what is expected that its presence keeps the community aware of the threat it is posed with. It needs to violently attach itself to the context of the site and the existing stadium. Making a structure and facade system work geometrically with one another and basing the design on this rationalized system does not violently engage the existing stadium. Simple circulation paths do not shift the inhabitation and use of the stadium enough to effectively transform it at all times into the shelter. First and foremost the proposed addition of shelter needs to mask the function of the stadium. It is shelter first and the civic function of the stadium is discovered within program of the shelter.

The layered facade strategy needs to be strengthened into the driving force behind the shelter. Layering of data needs to be the process of design, not an idea about cables forming the facade. The design process needs to be re-thought in order to capture the awesome power of the eminent threat, and the important role that shelter will play in the future of this community. This image needs to be brought back:



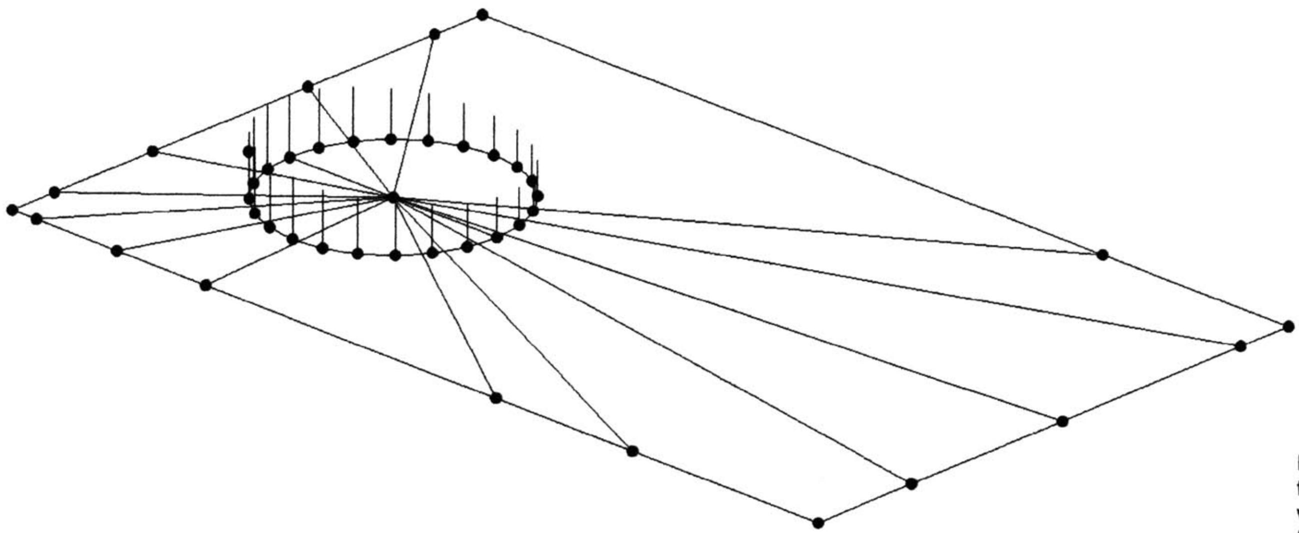
Shelter diagram 1

Soft Facade 2: Simple Inputs_Chaotic Output

Hurricanes form as a result of a few simple environmental conditions: warm air, low upper level winds and high sea surface temperatures. They are seeded by large storms that roll off the western coast of Africa and as they cross the Atlantic they slowly form into more intense low pressure systems. From this point the storm system starts down an unpredictable road of intensification, track and possible landfall. The inputs that create the hurricane are easily understood and monitored. Meteorologists know when the conditions are favorable for a storm to intensify into a hurricane, but are less adept at understanding what takes place as the storm progresses through its life cycle.

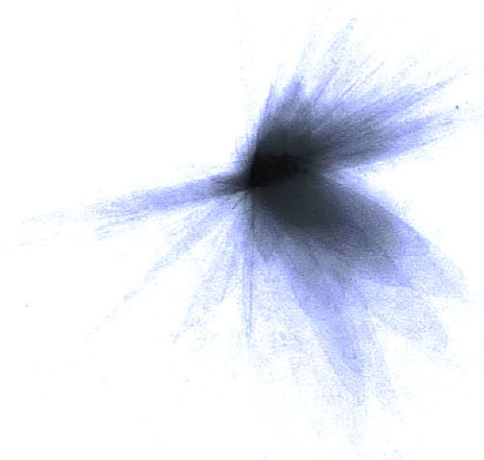
This condition of understanding inputs that feed into a system, but who's resultant is not predictable or fully understandable is the impetus for the final phase of the thesis. A simple Generative Components model was created that used a limited number of points (24 sets of 3 point in the case of the following drawings) to generate a series of arc's. 24 sets of points were chosen in order to tie the diagram back to the existing structural columns of the stadium. The point sets are tied back to points around the context of the site that relate to traffic flow. In the case of these first diagrams there are 13 points in the landscape that are adjusted to generate the differences in these layered fields.

The output of the system is roughly 1500 arc's which are then exported to Adobe Illustrator where they are given line thickness and transparency fills. This process is to extract from the arcs a condition of layered densities. In the case of these drawings this layered density can be seen as any of a number of possible relationships.

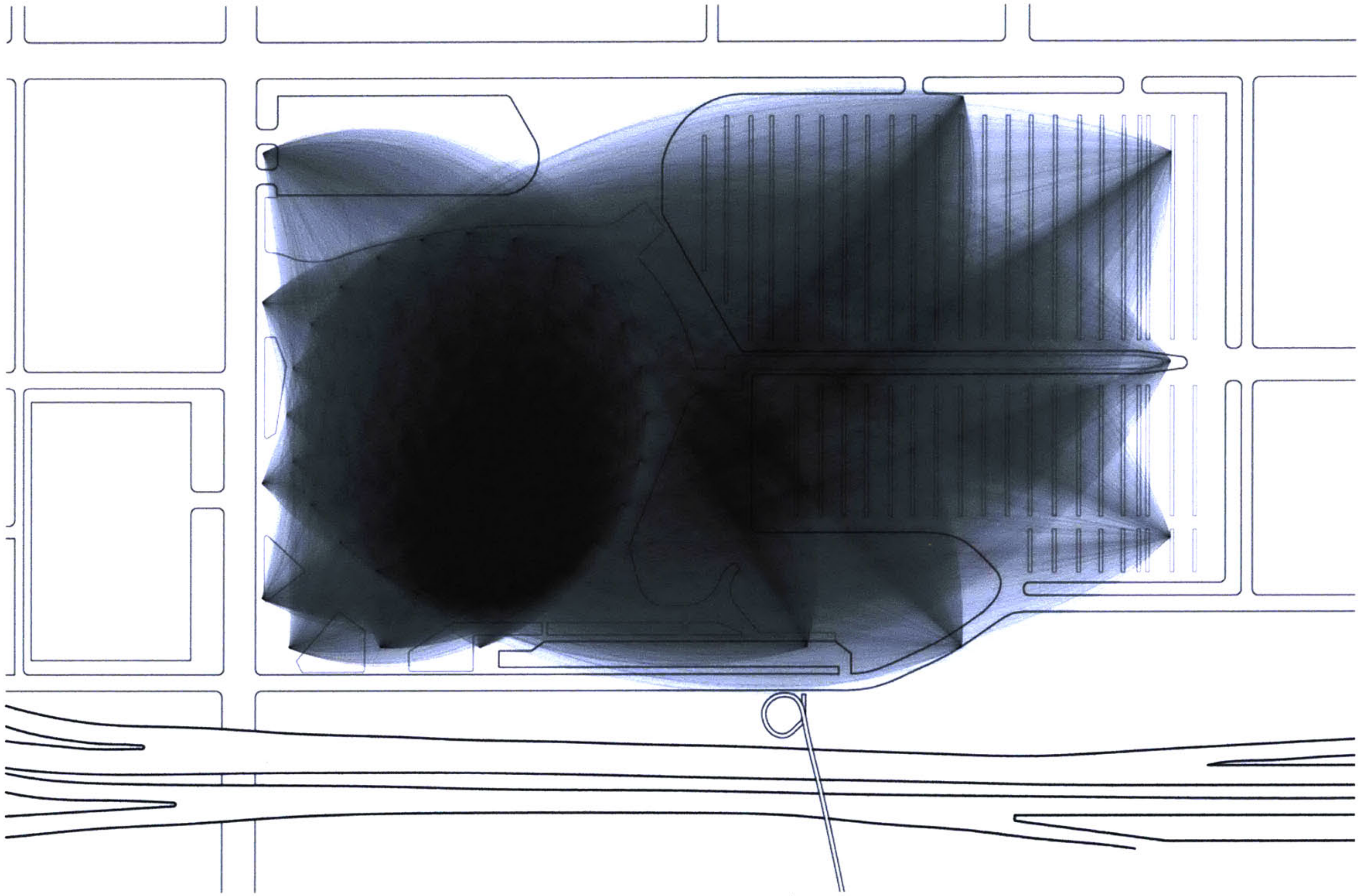


Frame work for generating arcs. The tops of the 24 columns are the end point while the start points are the 13 points at the periphery of the site.

Raw output from the system. This geometry produced the diagram on the previous page. The diagram on the following page was produced by decreasing the points on the periphery of the site. These points were also moved off the outer edge of the site to random points on the interior.



Shelter diagram 2



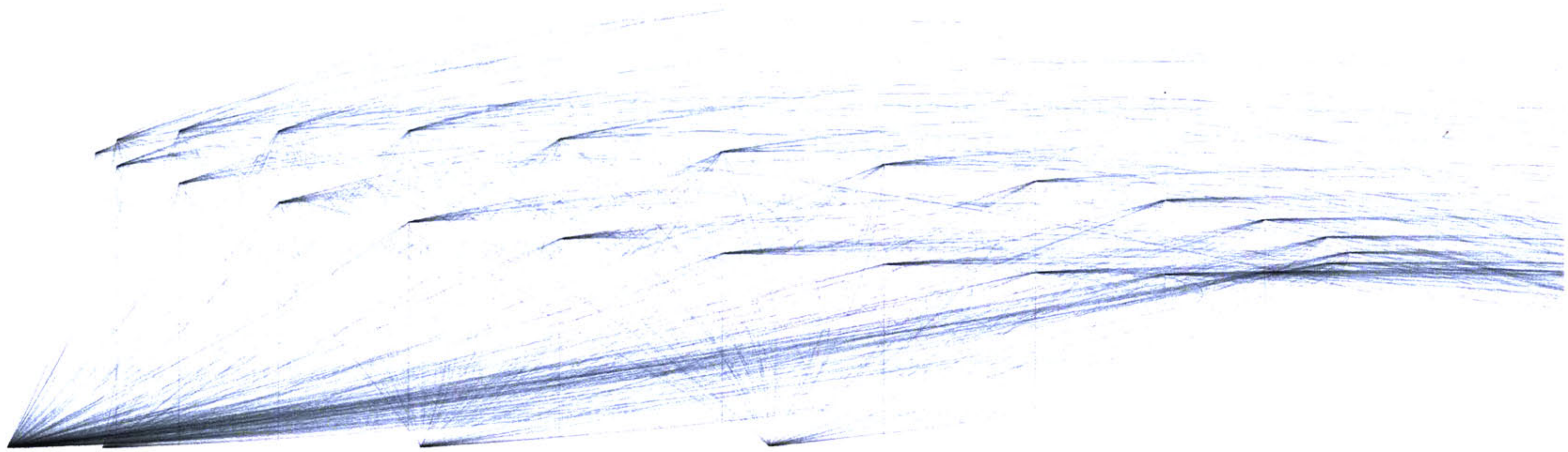
First plan generated from the parametric model.

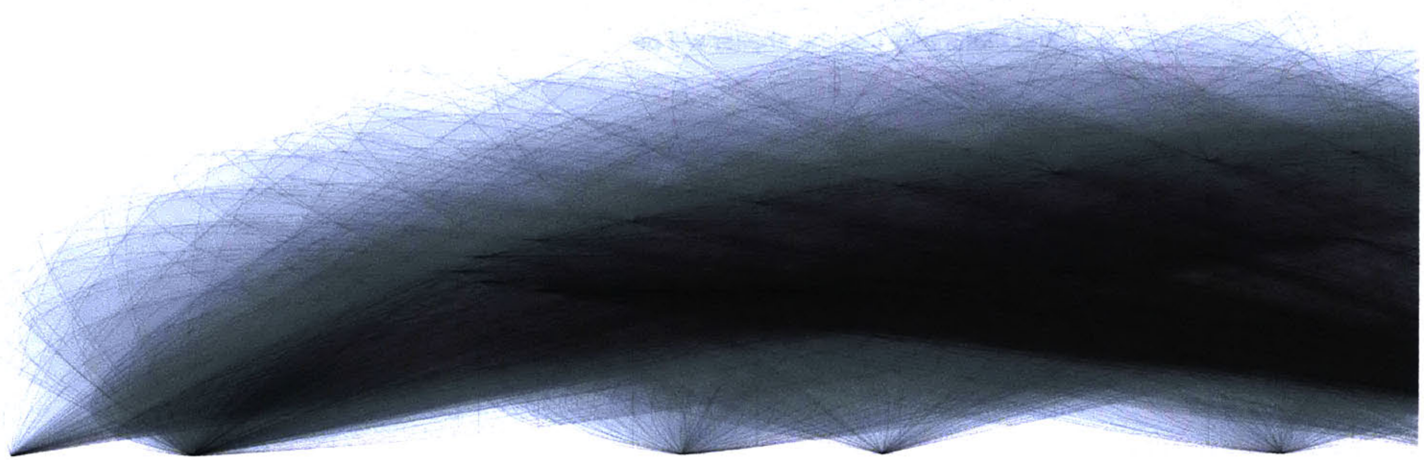
Soft Facade 2: Gaining Control and Attaching to Site

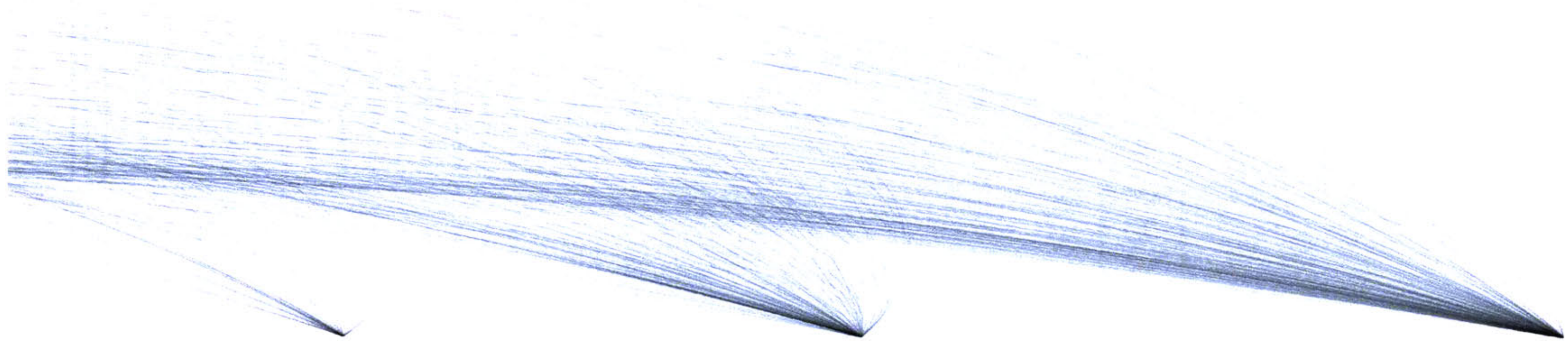
Using the techniques in the previous drawings, a relatively simple parametric model was created to test the possibility of generating plans for the shelter. The geometry is generated by using the same 24 sets of points, but now the start and middle points of the arcs are defined by site conditions. In the case of the three plan studies and their corresponding elevation/section studies the shifts in each's relationship to site conditions are defined mainly by the movement and circulation of people. In each plan increased area's of density, darker areas, form corridors of movement across the site and into the existing stadium. These areas are thought to be movement corridors and collection points across the site. People would park or walk into larger collection zones that filter into these areas of increased density which both provide physical protection from the environment and give order to circulation across the entire site.

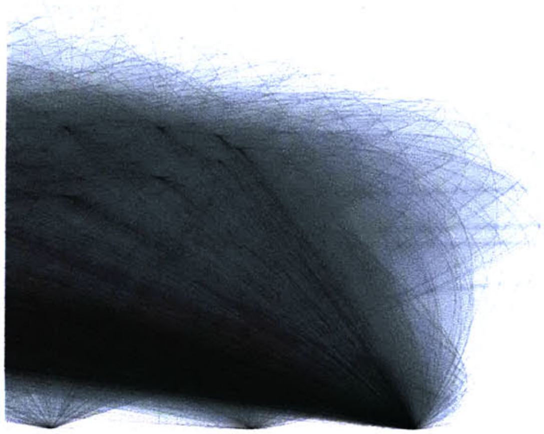
Each of the drawings created from this process are seen as the form of a building. They are permanent elements that exist whether people are arriving for a Sunday afternoon ball game or to escape an eminent threat. The chaotic and massive nature of these drawings are intended to capture what, in their built form, will become a civic apparatus that provides protection from a threat on all of the levels this thesis intended to make the shelter become.

The final set of drawings and renderings are intended to provide a further understanding of the scale, spatial quality and materiality that the shelter will be.

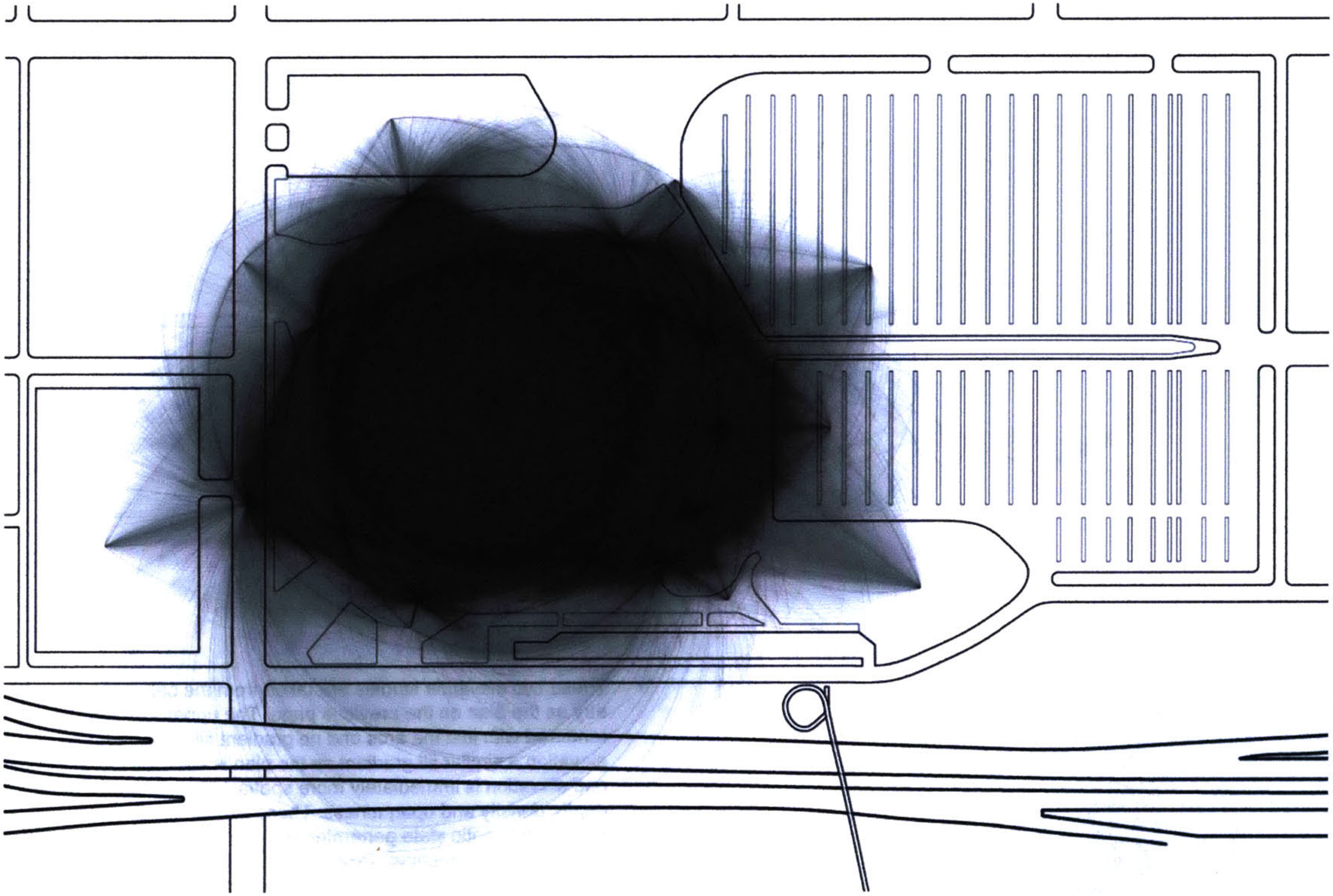






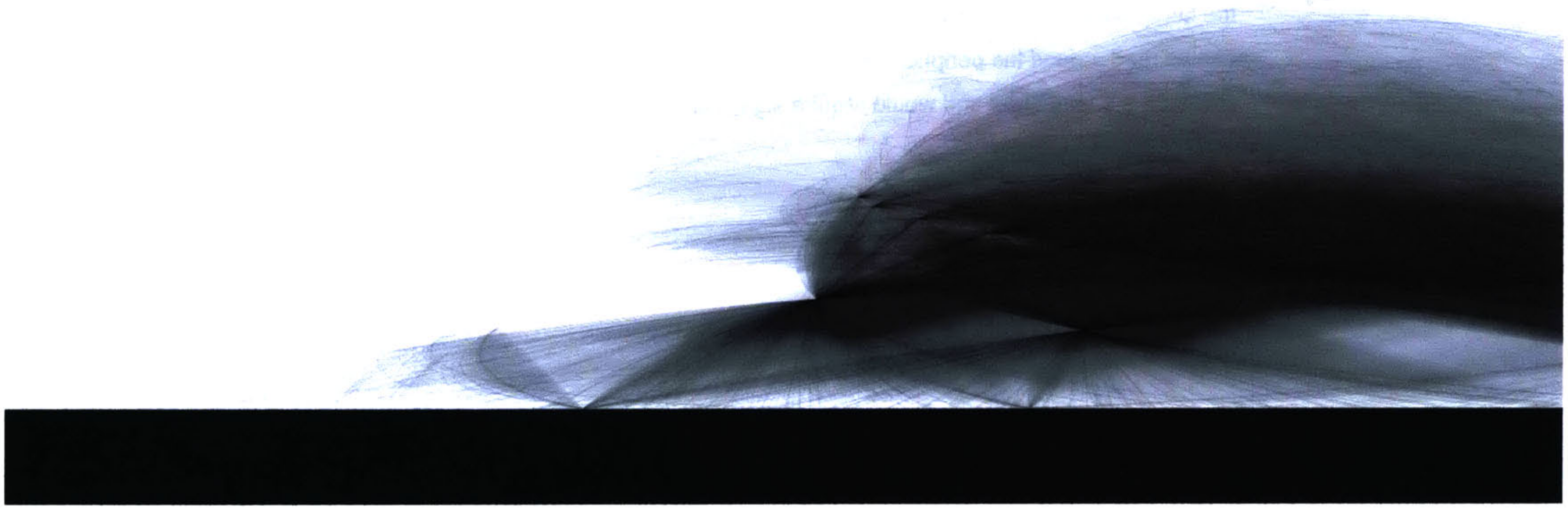


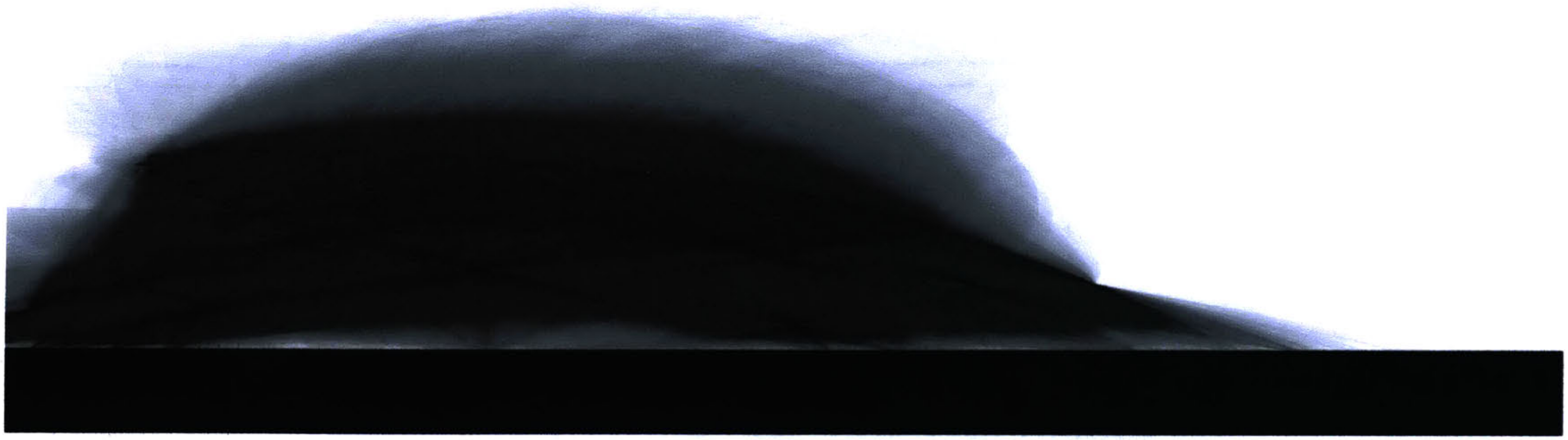
These two elevation studies are taken from the same geometry as the plan on the previous page. The upper elevation is rendered with just the arcs and no gradient fill. In the second elevation a similar fill gradient as the plan is applied. The second elevation is immediately more spatial because we can read depth, density and opaqueness. These elevations begin to capture a chaotic state generated out of a relatively simple set of parametric relationships. Taken as a facade study these begin to get back to the initial thought and formal quality of what a shelter should be.



Plan_Elevation study 2: Constricting the engagement with site

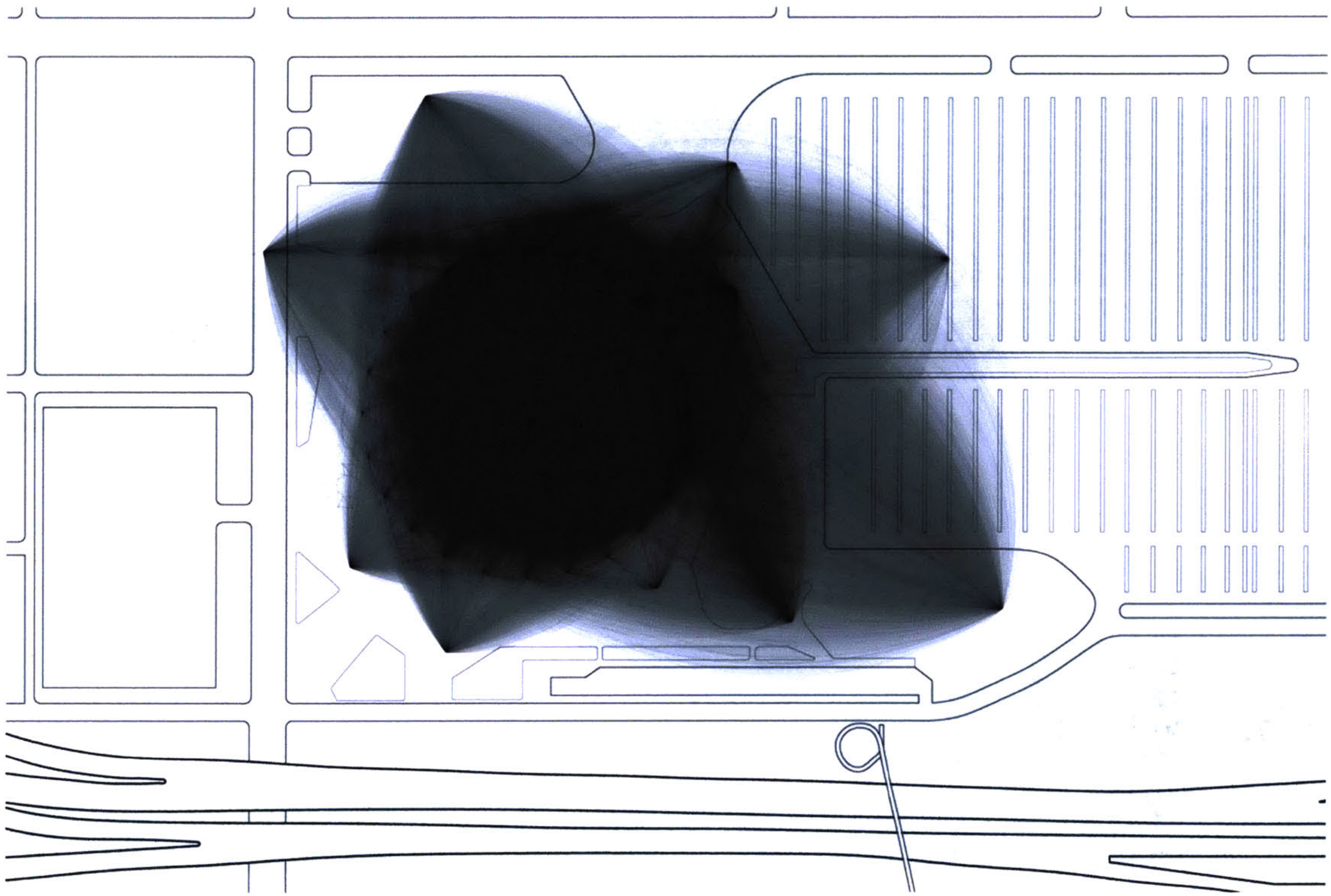
In this plan the points of engagement with the landscape are pulled close to the original stadium. There is a significant increase in the density around the core of the stadium. This increased density is helpful in certain areas because it can be seen as more immediate access into the space of the shelter, but come at the detriment of engaging the larger context. This is the closest study to the original thinking of the onion relationship. Extremely dense spaces can be read around the periphery of the existing stadium that could all become spaces of sheltering. The circulation corridors are very short and would require significant vertical circulation to access all spaces within the stadium.





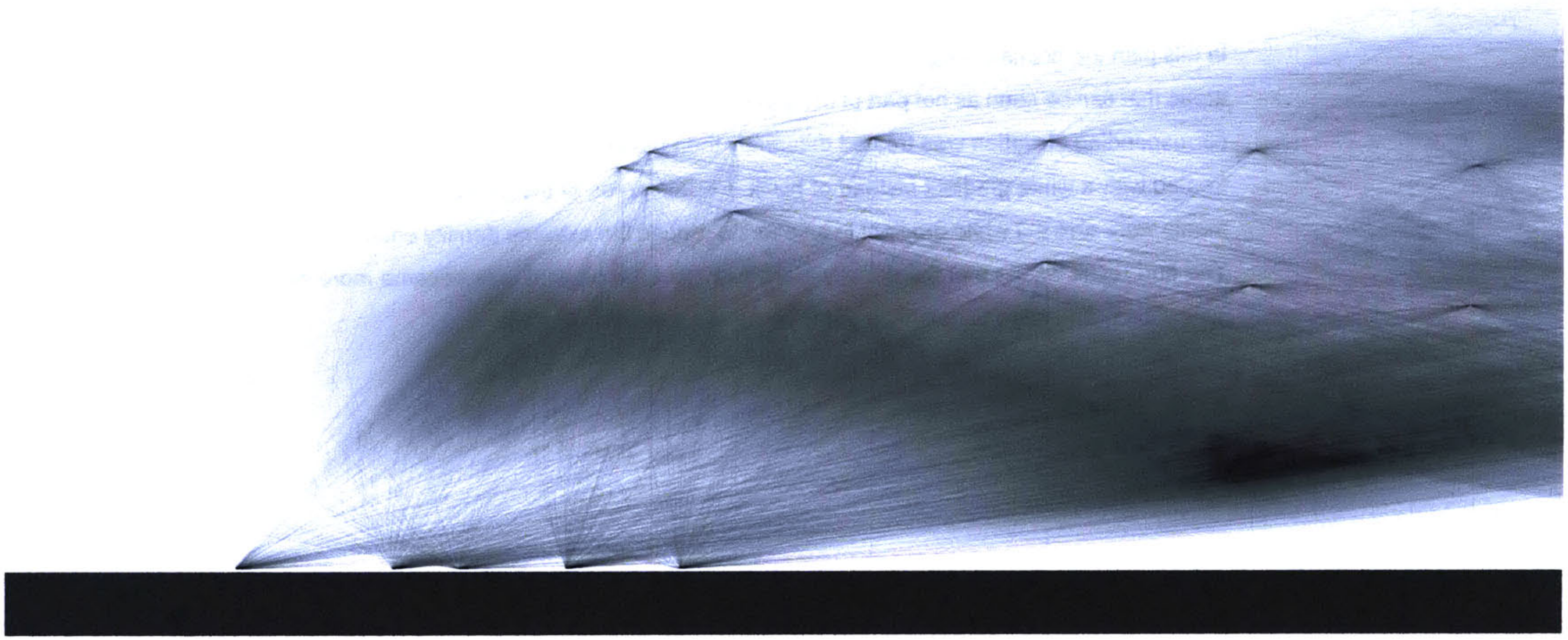
Elevation showing a similar density around
the core of the stadium as was in the plan.

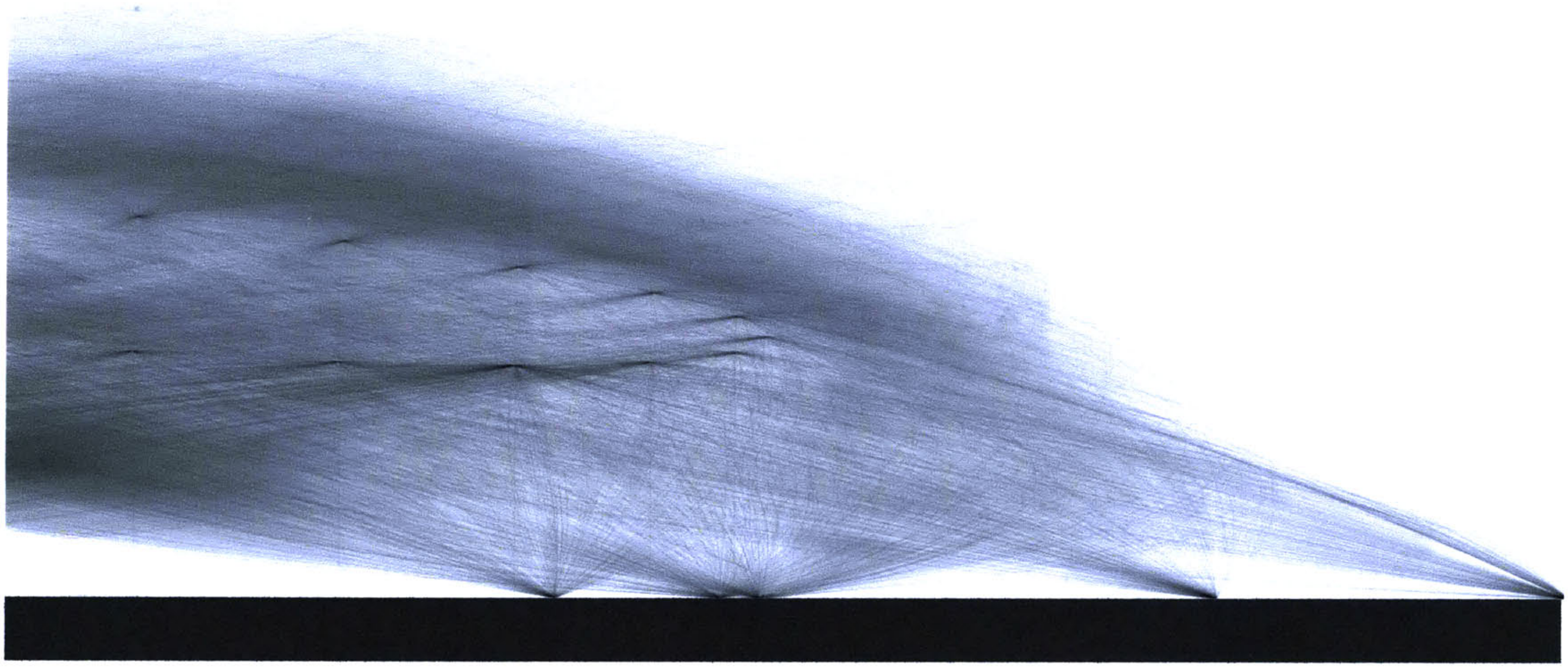
Section taken through the core of the stadium.



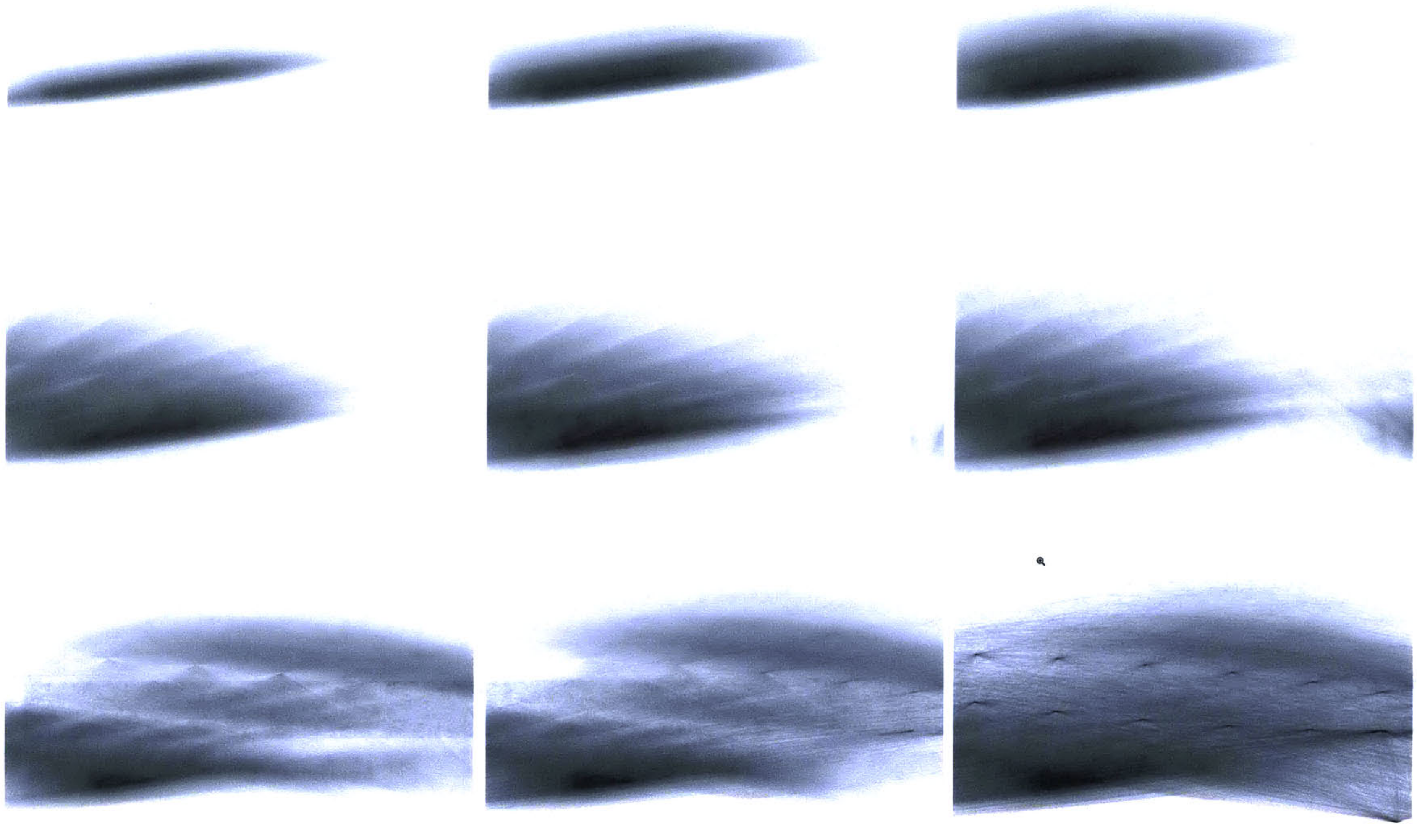
Plan_Elevation study 3: Middle Ground

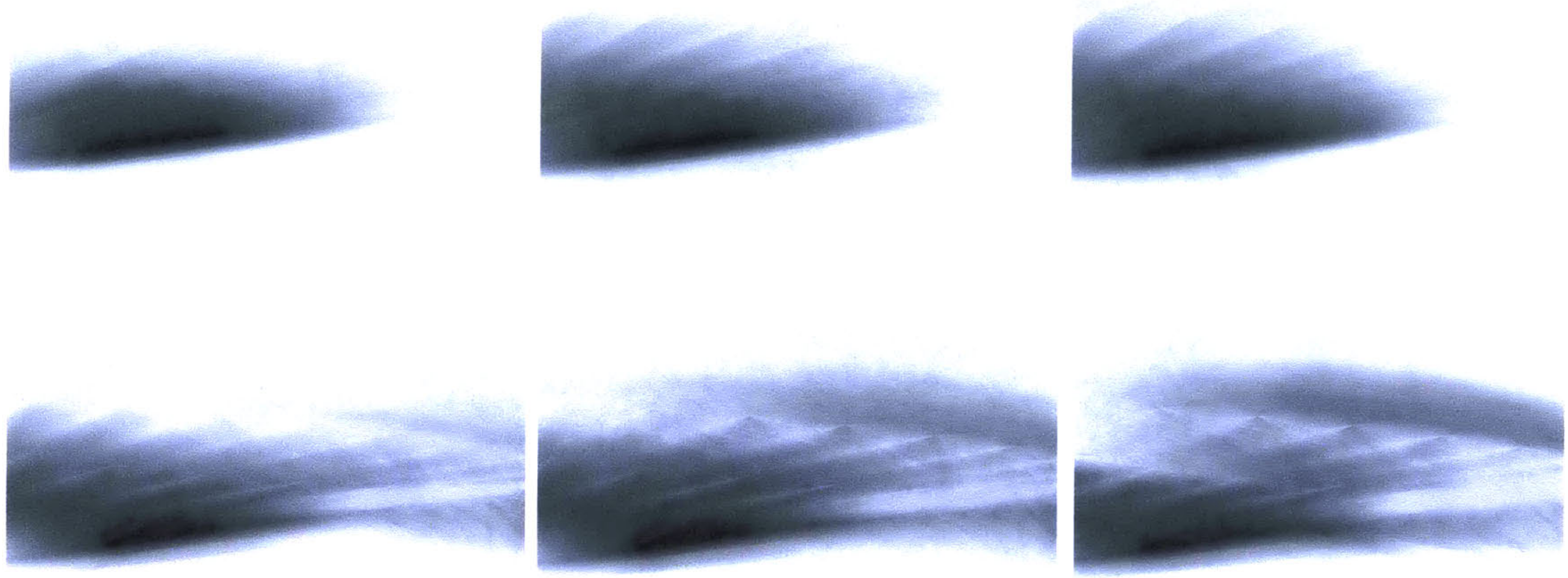
In this plan the points of engagement with the landscape are placed in a relative middle ground. They are placed in areas that can be seen as not part of the immediate space of the existing stadium nor part of the larger context. The corresponding elevation was treated differently then the previous two study's. In this elevation certain area's were treated with a white gradient instead of black. Certain areas of the elevation that represented large vertical movements were give the white gradient in an effort to reduce the extreme density encountered in the previous drawings. The end result wasn't that the density went away, but the original arcs became more evident in the final drawing. This allows the image to convey a great sense of structure and scale.





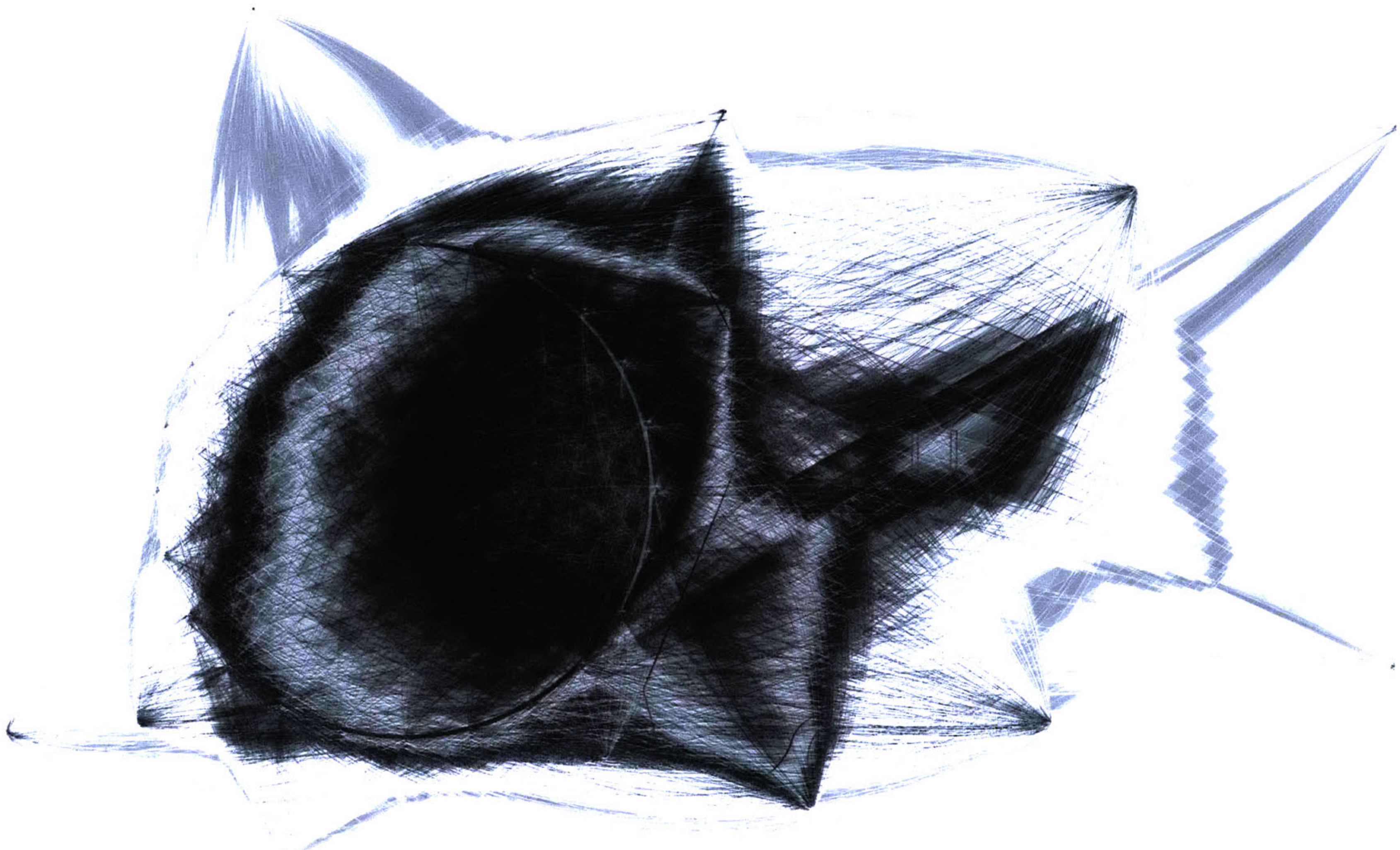
Elevation with both black and white gradients.



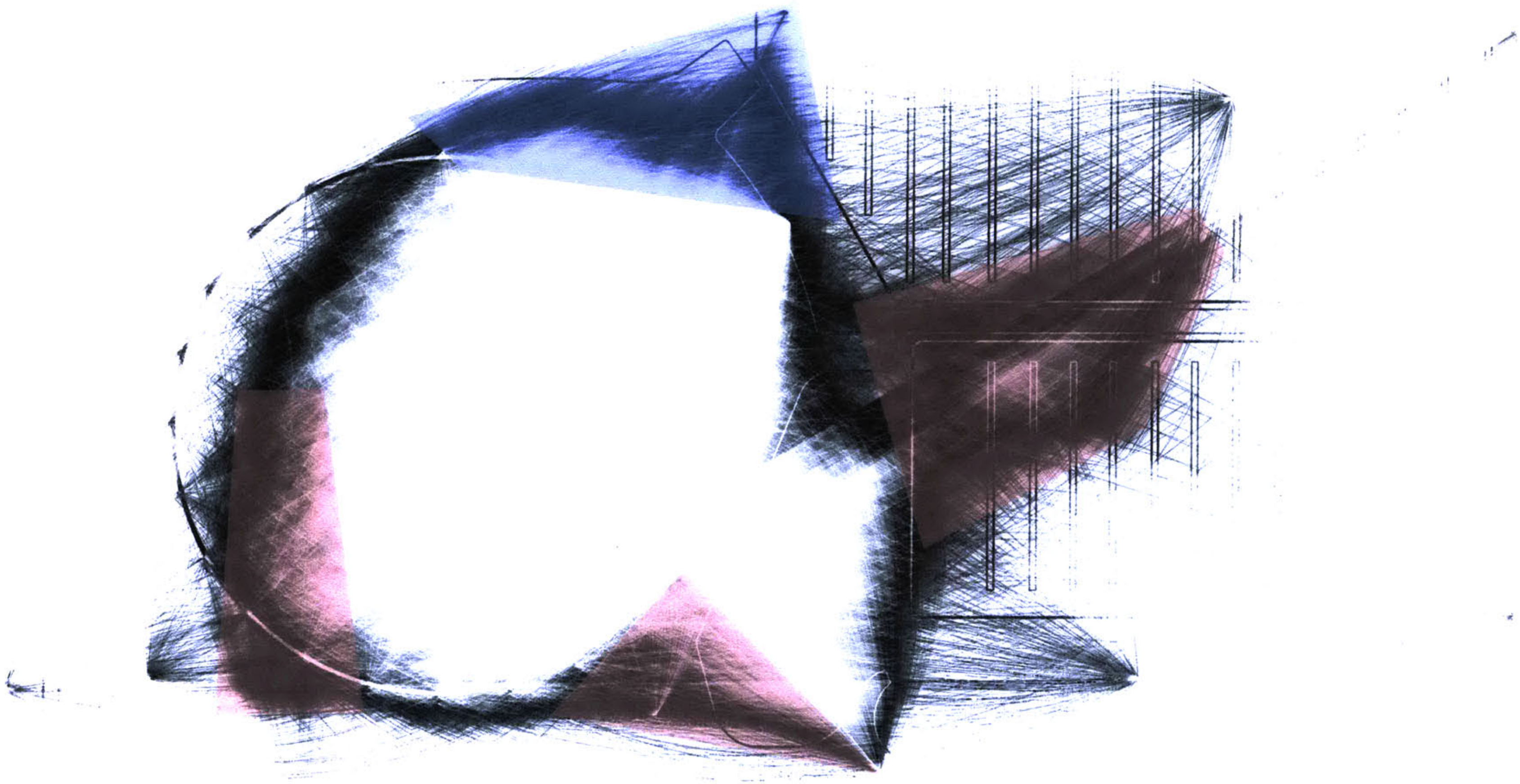


Layering

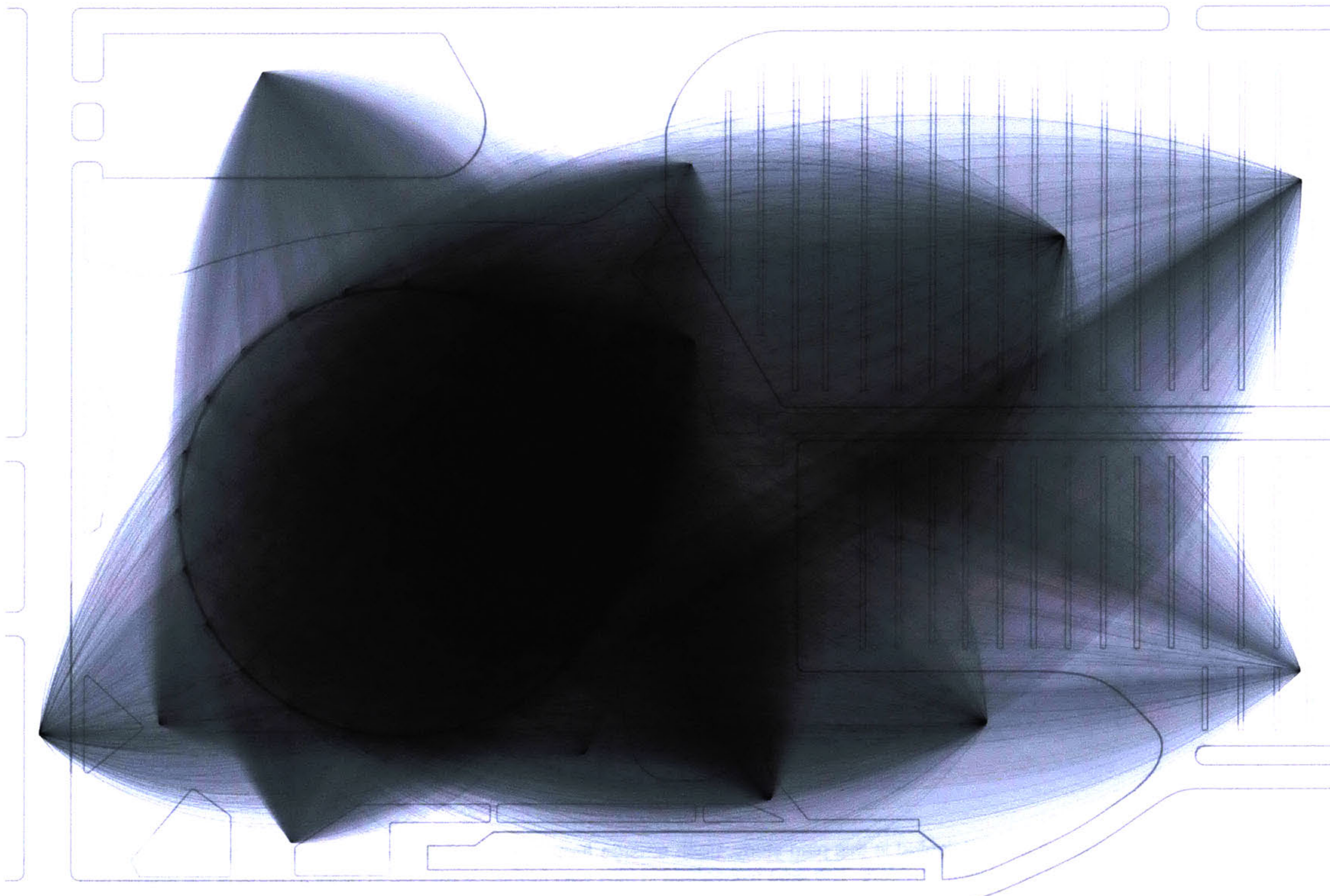
These frames capture the assembly of the elevation from the previous page. As more layers are added in each frame there is a greater sense of the possible spaces of the shelter. The connections to the existing 24 columns also begin to form as the different layers and gradients unveil a clearer geometric order.



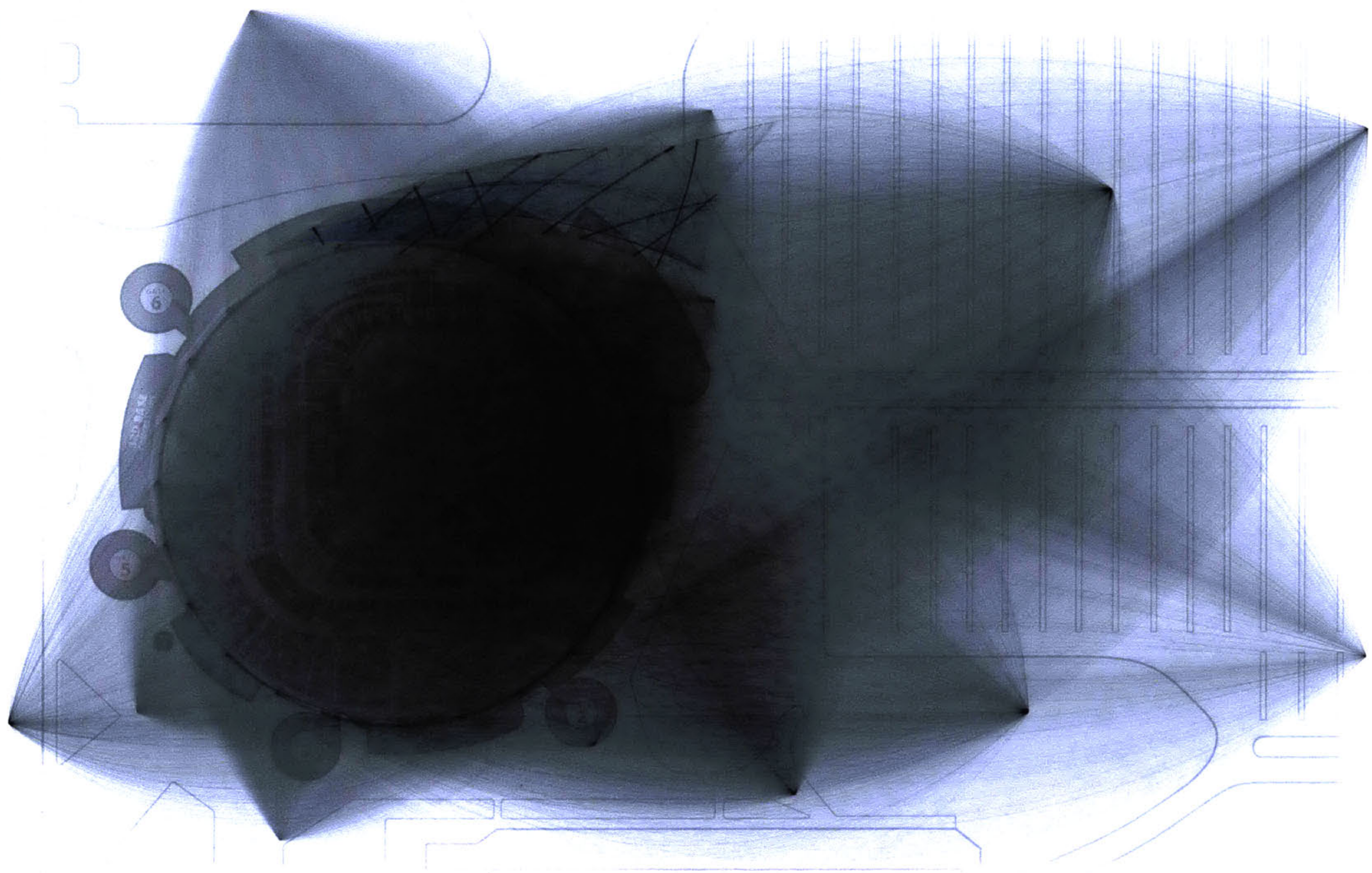
Extracting more spatial information from the plans was important to understanding where different zones of density were taking place. By using Photoshop to pull out specific levels of gray scale information, the plans quickly become less about density and more about zones. The darker areas that extend from the core of the stadium are key components to the shelter that engage the larger context.



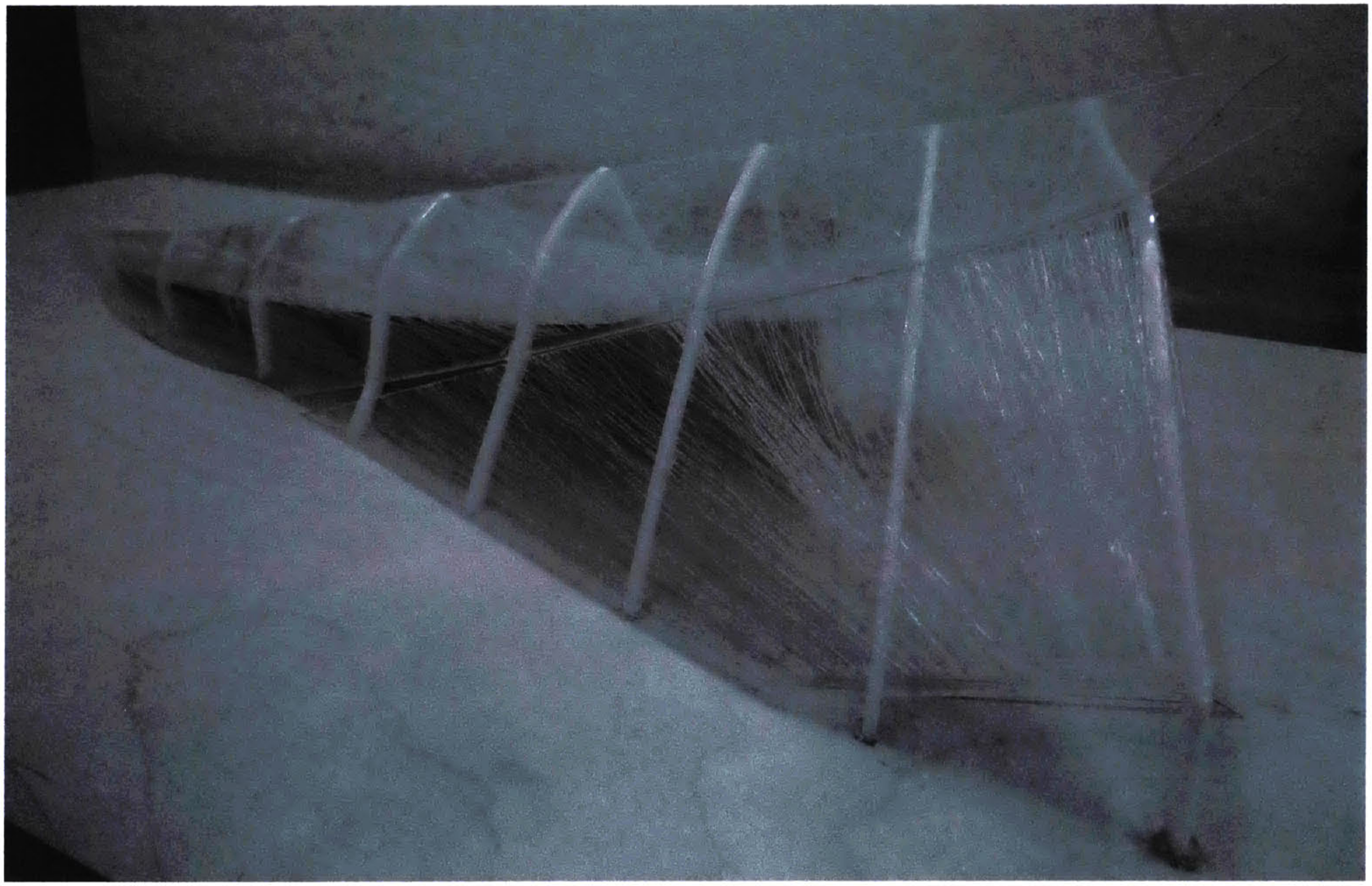
Four key areas of shelter program are highlighted in this plan study. Each emerge from the void of the existing stadium, the most protected area, and engage portions of the site as circulation corridors. The area highlighted in blue was further developed in order to engage the spatial and material qualities the rest of the project might adopt. Finding a possible materiality for the project returned to the idea of a cable net formed over larger structural members.



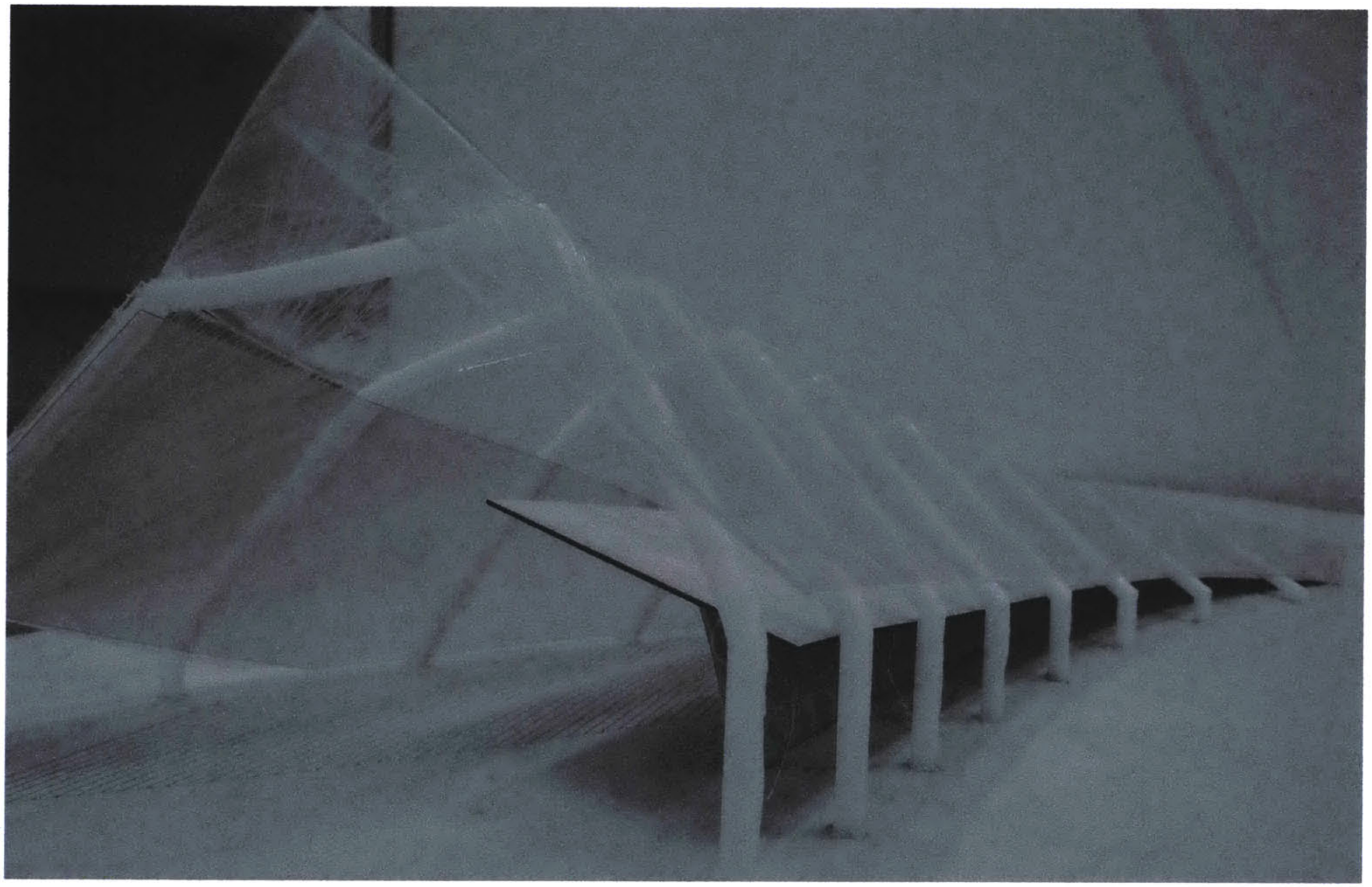
Final Plan with no detail. The final plan is a composite of elements from each of the three plan studies. Each plan offered elements that helped bolster the effectiveness of the stadium/shelter relationship baed on engagement with the landscape and the density of space formed around the core.



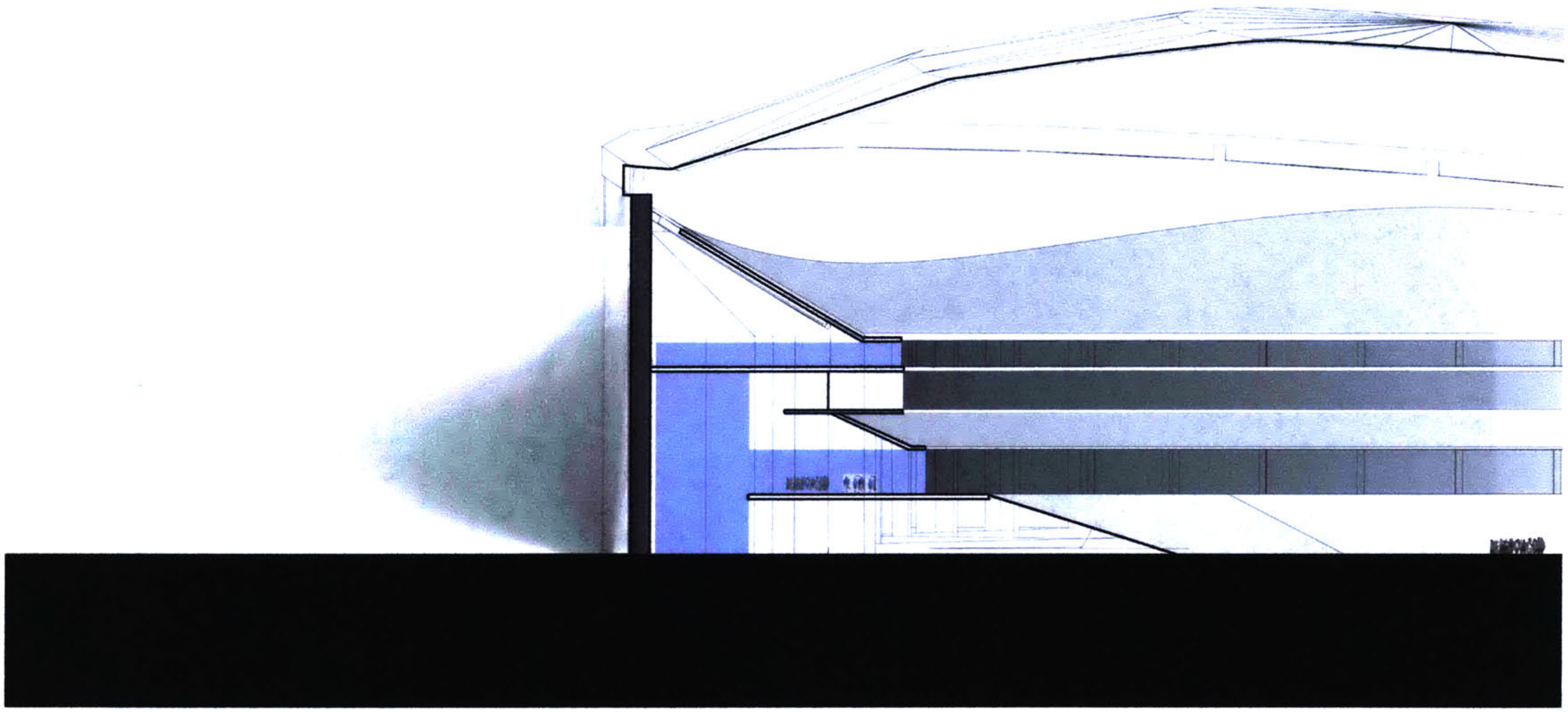
Final Plan with details on the existing stadium and the
addition of the further developed element.

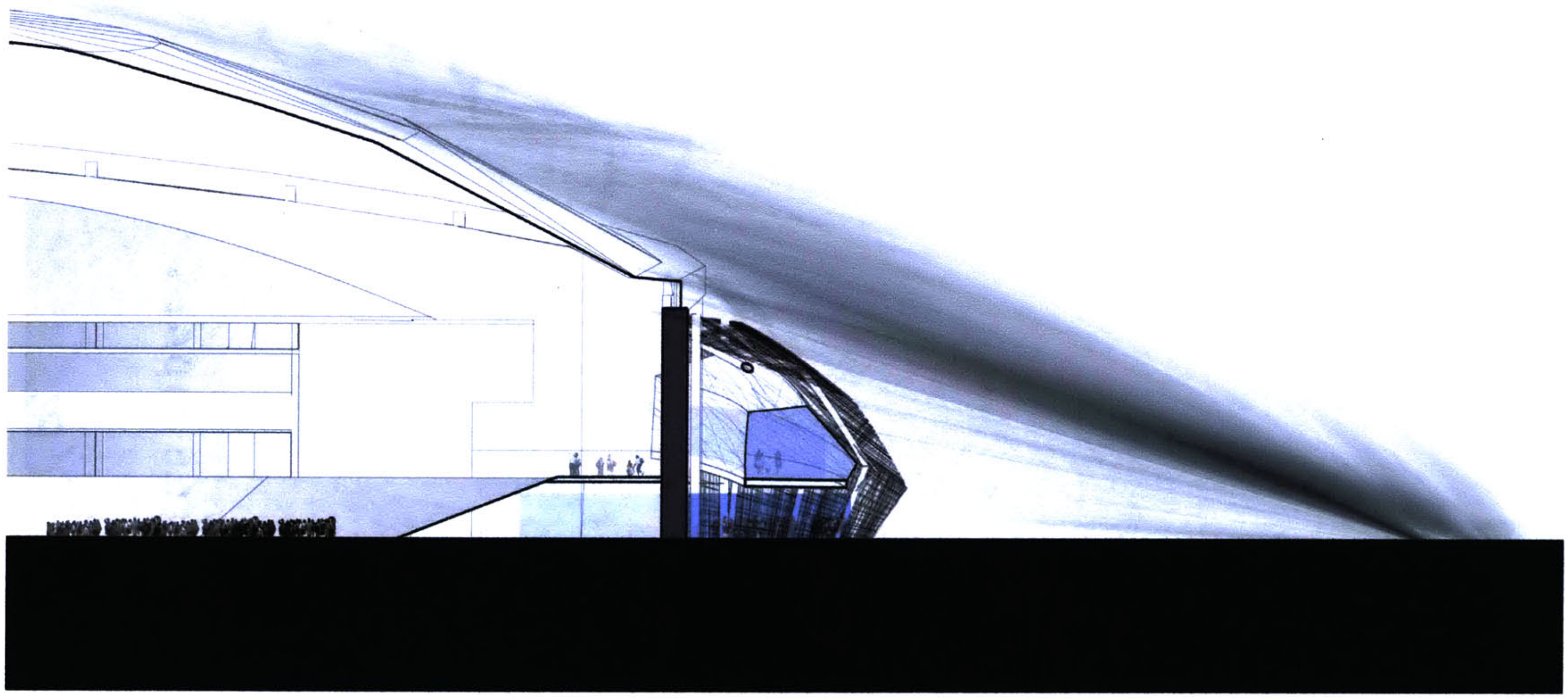


Phyiscal model test of materiality and structure.

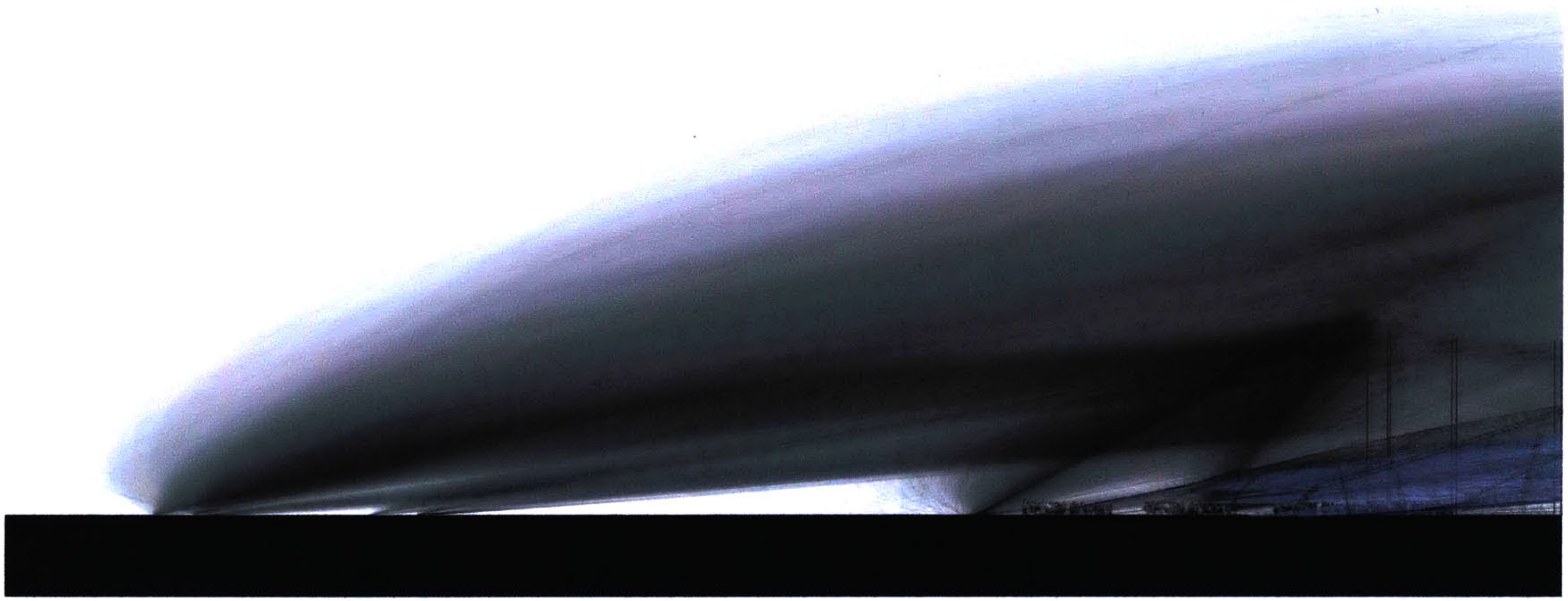


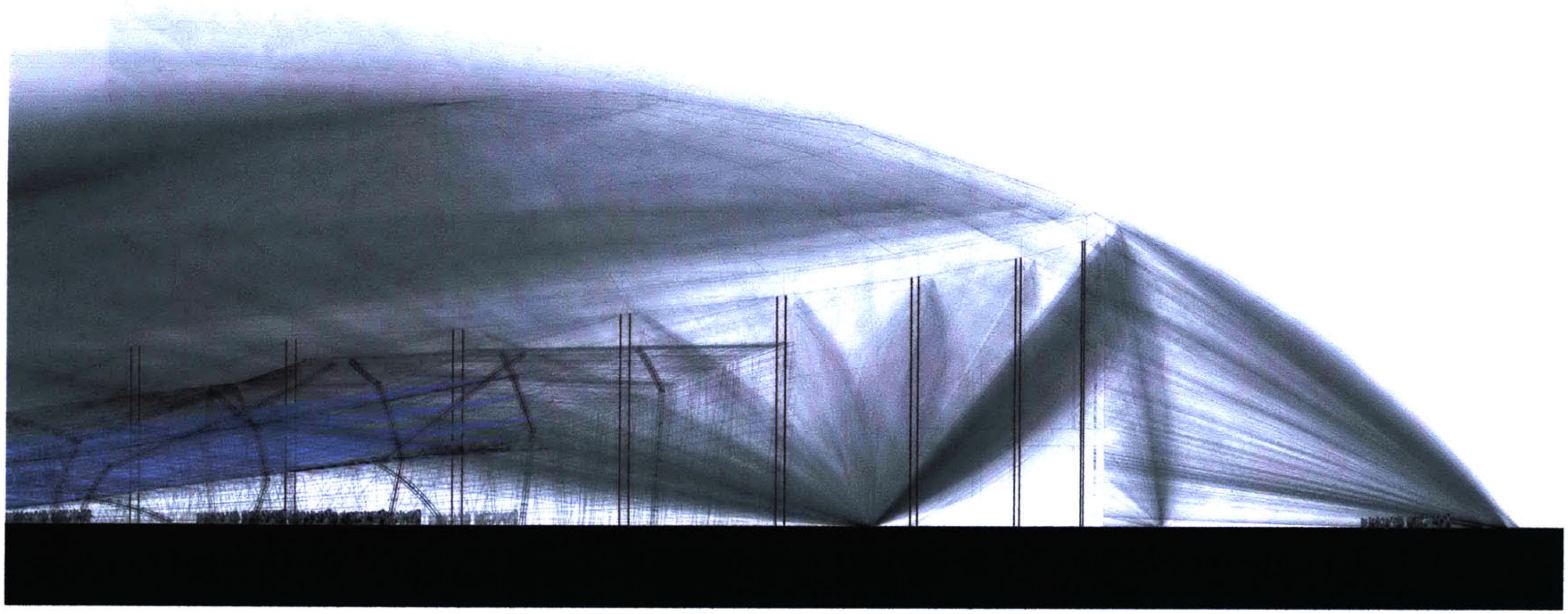
Phyiscal model test of materiality and structure.



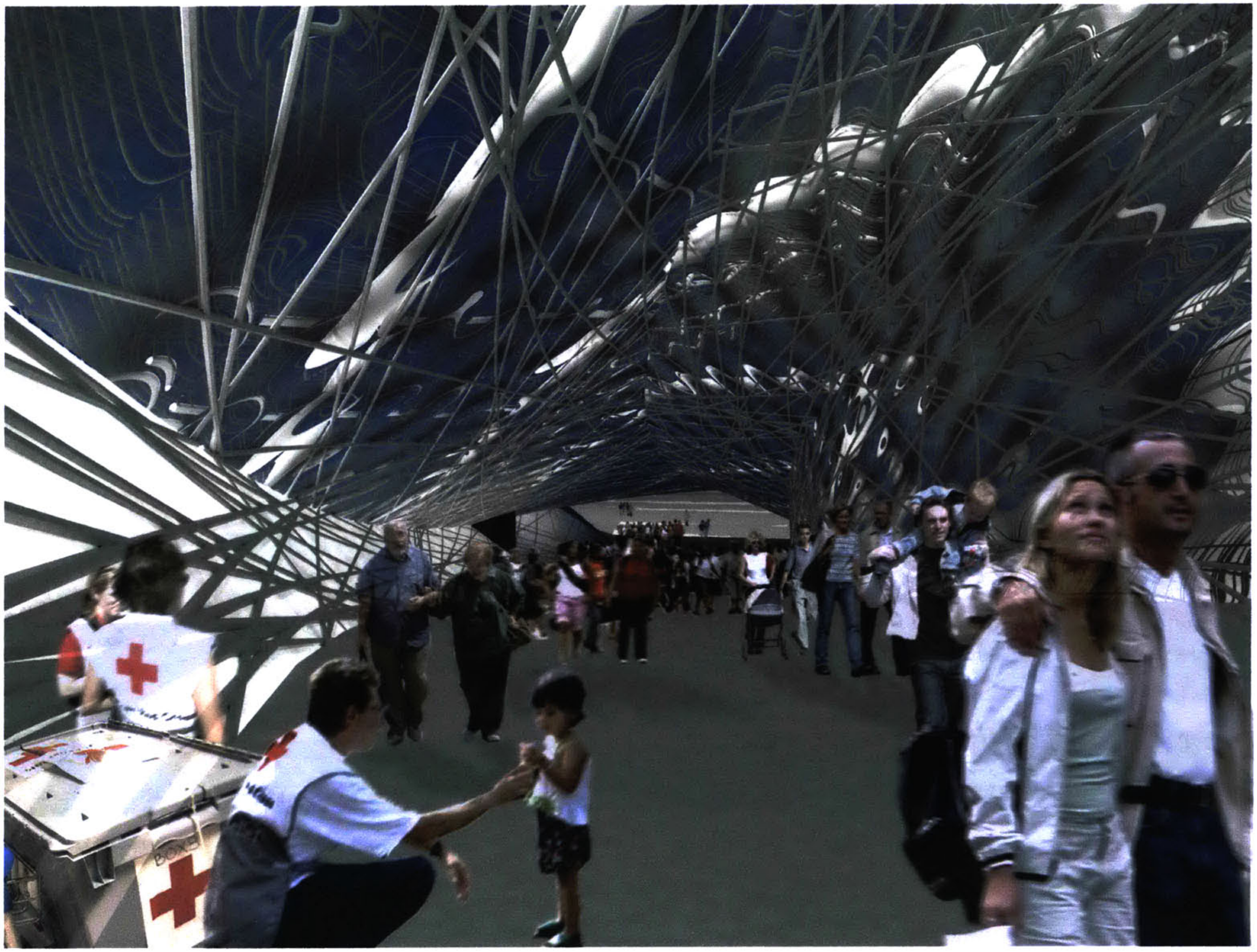


Section taken through the existing stadium. Blue areas high-light circulation/shelter areas.

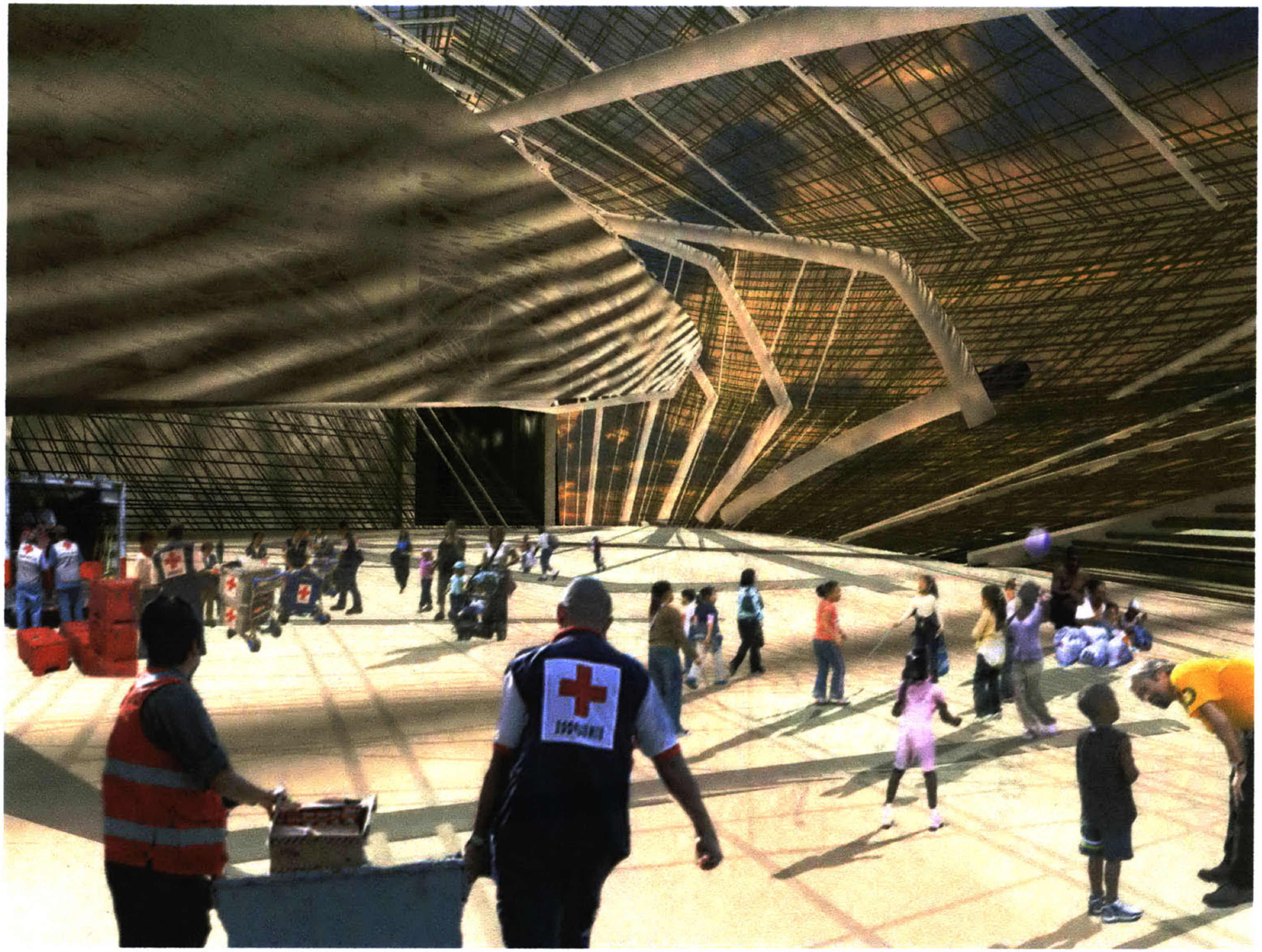




Elevation looking to the south

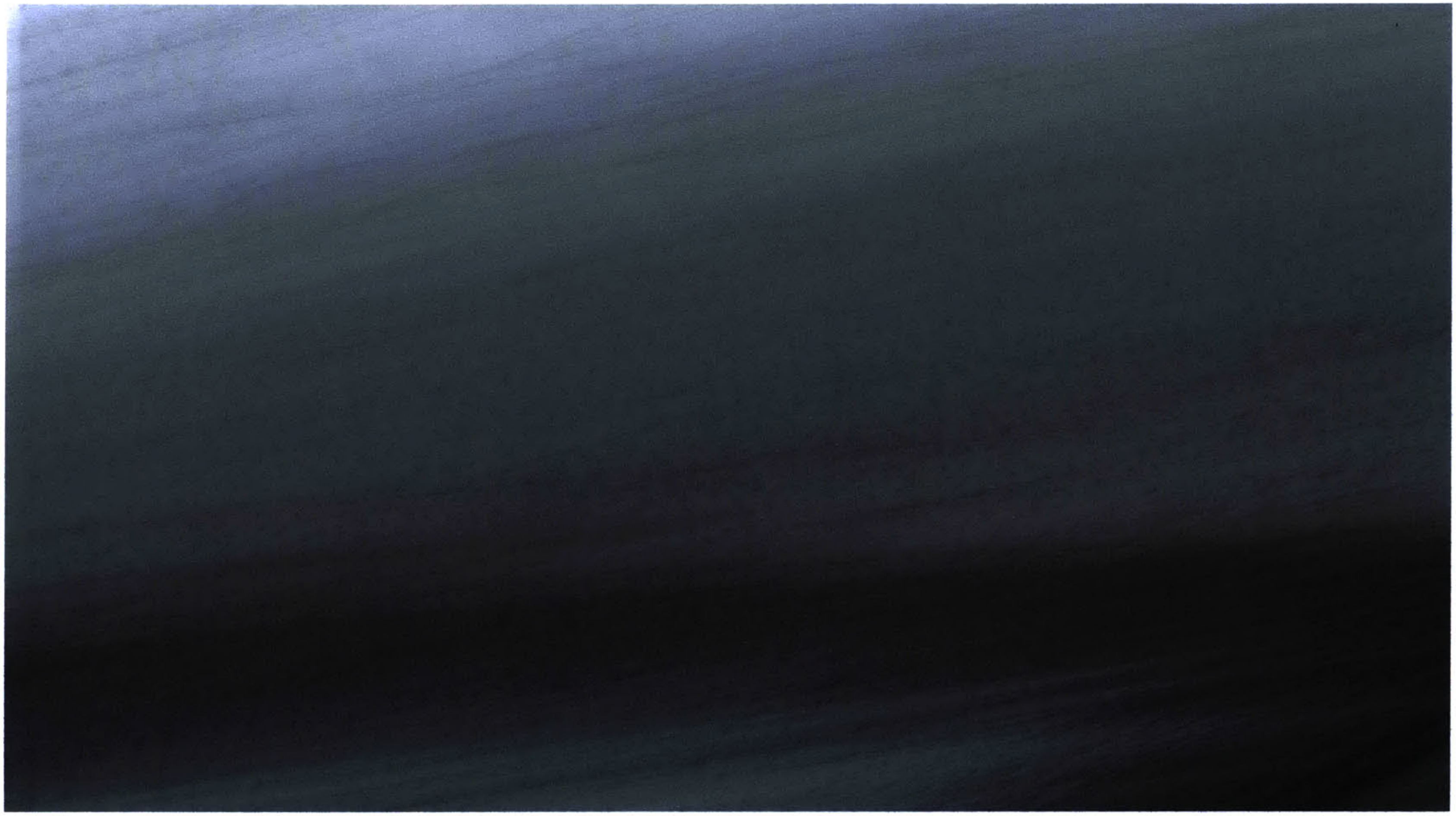


Rendering from inside one of the more enclosed spaces of the shelter. The chaotic structural elements have translucent air cushions filling the void between them to give a weather proof enclosure.



Post storm image showing the most exterior skin of the shelter. A carbon fibre net over a portal frame structure form the skin. The image on the opposite page is taken from within the tube structure in the upper left of this image.

The glowing shelter as the storm approaches.



Conclusion

During the course of this thesis it became evident that architecture must engage the emotions of people when being proposed as a solution to a very real threat. I have been constantly bothered by the "incompleteness" of this thesis in terms of structure, materiality, spatial functionality etc...; however In presenting the thesis I found that the project immediately engaged people into a discussion about their readiness for a storm, and a new understanding of the issues facing their community even though it wasn't solved as a building. The thesis is then successful in that it accomplishes what it set out to address. People who have seen the project that live in Pinellas County were immediately frightened by the peril that exists and taken back by the images of the project. I hope that the information and images stay with them keeping them aware of a threat so awesome that it will change forever the community they live within.

The project must be pushed forward and try to solve how these images can be translated into physical construction, this is the challenge and excitement of architecture. While the scope of this thesis stops at the level of completion in this book, the project will not.

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